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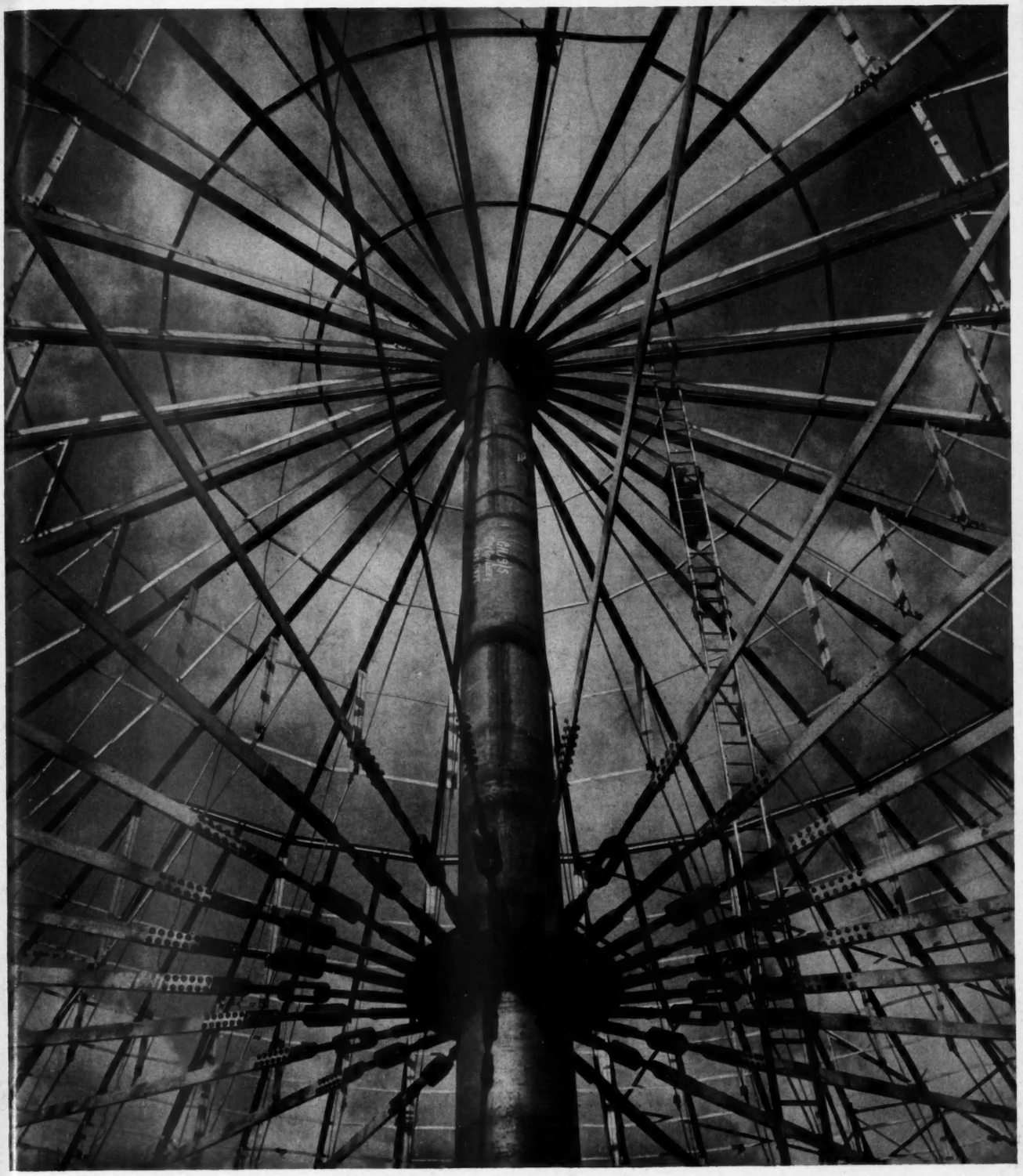
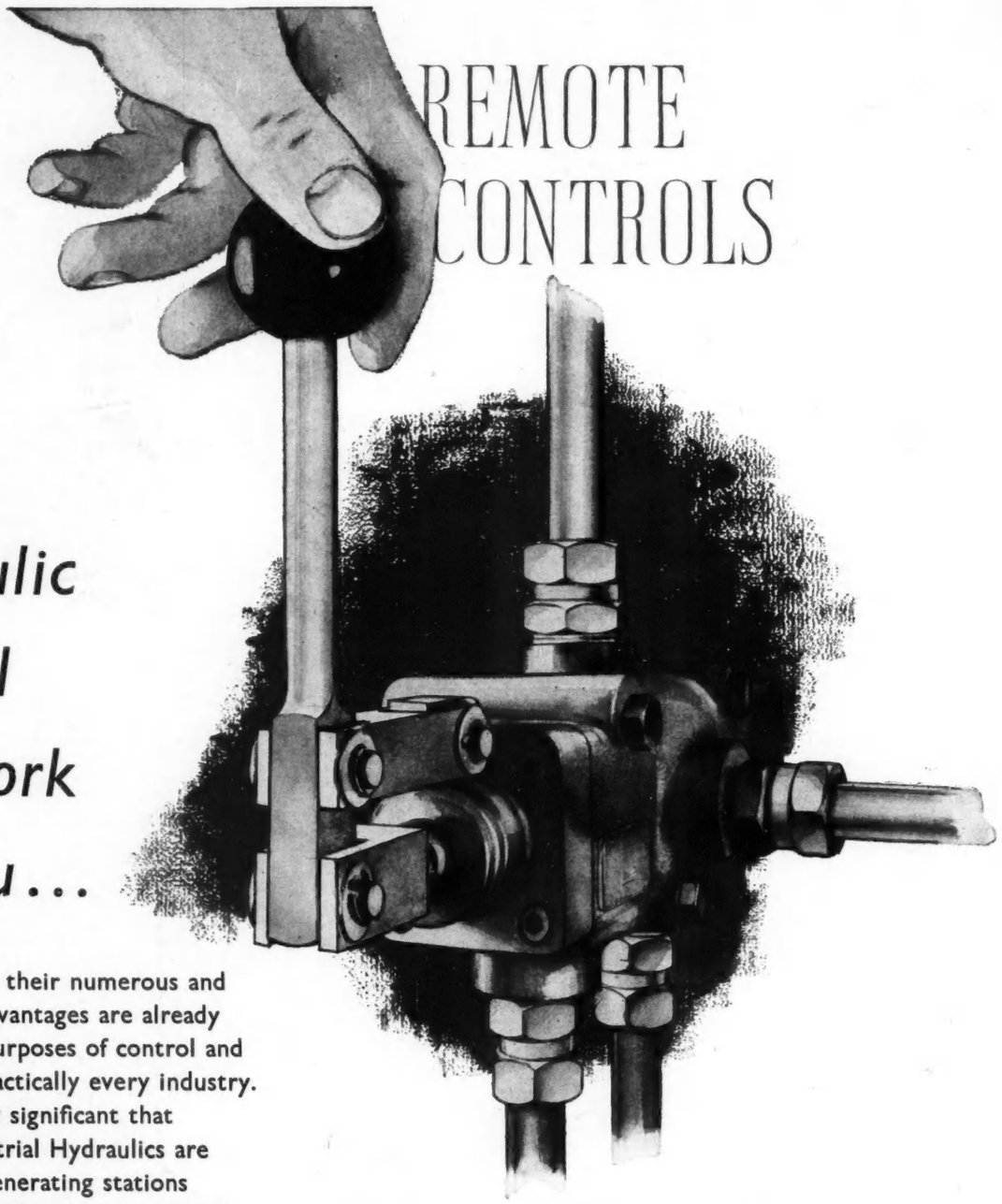


CROWN FRAME OF A LARGE GASHOLDER

REMOTE CONTROLS



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ENGINEERING

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Vol. 178 No. 4621 AUGUST 20, 1954

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DESIGNER AND USER

THE satisfactory performance of engineering equipment depends in varying proportions upon its design, manufacture, operation and maintenance. Good design will be marred if the materials used in the product are of inadequate quality or the constructional processes badly planned, while poor design cannot be fully compensated even in the best organised workshop. Moreover, injudicious methods of operation and lack of attention to maintenance may do much to offset any advantages gained in the other two spheres. To achieve the best results it is therefore necessary to employ what, in another connection, are known as " feed back " methods: the designer and manufacturer must continually be guided by the experience of the user, and the user, for his part, must rely on the knowledge of the designer and manufacturer to satisfy his requirements in the most efficient and economical way.

These observations could be illustrated by a number of examples from all branches of engineering. We have, however, selected for consideration certain phenomena which affect the manufacture and operation of the electrical equipment on Diesel-electric locomotives. This subject is dealt with in some detail in an article by Mr. C. A. Atwell which appears in *Electrical Engineering* (the journal of the American Institute of Electrical Engineers) for July, 1954. It may be postulated that the frame of such a locomotive is not an ideal position for apparatus of this kind, for it is subjected to shocks and vibration which may at times be severe and is exposed to dust and other harmful weather conditions which may render its maintenance at a safe temperature difficult. It operates under a constantly changing load which extends over a wide range, and where rheostatic braking is employed excessive voltages may occur when the speed is high. It is not surprising therefore that flashing at the commutators of the generators and motors of Diesel-electric locomotives is the rule rather than the exception.

This flashing is of several kinds, the most common being due to arcing at the points where the commutator bars leave the trailing edges of the brushes, and to " ring fire," which is the result of small arcs between one or more pairs of adjacent commutator bars. Although neither of these causes is usually very destructive in itself, either may develop into a more serious arc which extends over the surface of the commutator between adjacent brush holders. The result is a flash-over which may be destructive if it is allowed to continue even for a fraction of a second. In general terms these flash-overs may be due to any cause which brings about large and sudden changes in the current, such as rough or eccentric commutators (caused by running above the maximum permissible speeds and thus imposing strains on the bars); worn brushes, which may lead to trouble even on smooth tracks; loose connections and short-circuits; the opening or closing of the main contactors under heavy loads; faulty operation of both contactors and relays; and power reversals when the locomotive is moving, to mention only a few. All these give rise to surges which result in a rapid irregular variation of the armature and field currents and terminal voltage. In fact, if the excess current reaches a fairly definite value, flash-over may occur in a time calculated in fractions of a second. Thereafter its results may be so serious that the locomotive will have to be taken out of service or the generator or motor removed for repair.

It is clear from this analysis that the commutators form the weak link in the chain, and that those on the traction motors are the most vulnerable. For where a flash-over occurs on a motor a large current rush is set up, which practically short-circuits the generator and may cause severe damage unless it is extinguished by reducing the voltage and cutting off the engine. Moreover, the originating surges are mainly due to the switching operations necessary for changing from power to braking, from series to parallel connection and for field shunting. To ensure that these operations occur without giving rise to trouble careful design is necessary, especially of any automatic apparatus that may be installed, while attention to the lay-out of connections is a point which must not be overlooked.

Although most of these aspects are the responsibility of the designer and manufacturer, either alone or in combination, the operator has also an important, if simpler, part to play. As Mr. Atwell rightly insists, much more could be done to keep the plant clean and thus remove a vital pre-disposing cause of trouble. This duty is, of course, facilitated by making arrangements for the supply of clean cooling air and rendering all the apparatus readily accessible. But this and other design problems connected with flash-over would seem now to be well understood and, from the designer's point of view, not insoluble. Solved, that is to say, if the equipment is operated intelligently and maintained carefully. If the user is prepared to take quite simple precautions the designer can often be relieved of the task of introducing unnecessary and expensive complications.

Weekly Survey

GERMAN LABOUR UNREST

No country has made greater economic progress since the war than Western Germany. Industrial output has increased rapidly and exports, principally of engineering goods, have gone on increasing their share of the world market. This has not been achieved without sacrifice; the public has had to endure fairly stringent austerity in order to provide the capital resources urgently required by industry to repair the ravages of war and extend capacity. In 1952, investment in fixed assets was estimated in Germany at £2,100 million, 35 per cent. higher than in 1936, and, notwithstanding the slightly smaller population, somewhat more than in the United Kingdom. Since 1952, it has increased still further and, in addition, by granting substantial long-term credits in order to encourage exports, Germany has in effect been undertaking a heavy programme of foreign investment.

The heavy investment policy, although indisputably successful, has not passed uncriticised. Inevitably, some of it must have been directed to uses which may show little return, and the workpeople have felt that the growing rewards which are being reaped are serving to increase industrial profits rather than wages. Higher wages, unless in fact they can be met out of profits, must also reduce the volume of investment, including the amount of credit which can be granted to foreign customers – a vital factor in the maintenance of the German export trade.

British manufacturers of engineering goods may, of course, benefit immediately from a higher level of wages in Germany, but it must be remembered that in the long run German prosperity is necessary to a healthy European and world economy. The feeling of dissatisfaction has now, at the height of the country's prosperity, expressed itself in a wave of wage demands from unions representing over 4 million workpeople. The strike in the Bavarian metal industry does not appear to have had the full support of all the workers, but there can be no doubt about the general strength of support for higher wages in Germany. It is also likely that employers will have to concede most of the demand, as shown by experience in Hamburg where, in order to end the strike, it has been necessary to accede to the minimum demands of the municipal workers.

Whether in fact Germany can afford the wage increases is doubtful. In the past, the competitive ability of German manufacturers has depended upon their relatively low wage costs, despite which, because of high raw material and credit costs, their prices have been generally as high as those of their competitors.

* * *

ENGINEERING WAGES

At their conference last Friday, the unions of the Confederation of Shipbuilding and Engineering Unions were unanimous in their decision to press for a revised wages structure. This, however, disguised a very real conflict of opinion about basic issues. The craft unions supported the motion primarily to secure for themselves higher differential payments for skilled labour, while the unions representing unskilled workers were naturally thinking primarily of general increases. The delegates of the Transport and General Workers' Union, it is true, showed their support for a system of greater differentials, but they emphasised that the needs of the lowest-paid workers must first be met. Some were clearly in favour of higher differentials solely as an academic principle, but the general impression given by the debate was that a very high proportion of the delegates were thinking in terms of a general increase in wages in the near future.

It will be unfortunate if the undeniable need for a revised wages structure results only in pressure for higher wages. Two Courts of Inquiry have already recommended simplification of the structure, and a sub-committee of the Engineering and Allied Employers' National Federation has examined the possibility of revision. Something worthwhile might therefore come of negotiations in which both parties took full account of the urgent need to raise productivity, and were anxious to achieve a wages structure which would provide the maximum incentives. The executive of the Confederation of Shipbuilding and Engineering Unions may be able to pursue this objective in the terms of reference of the resolution. But although no time limit has been set to the period in which they may conduct negotiations, it is clear that their whole approach will be influenced by the general expectation among members of the Confederation of a fairly immediate increase in wages. Mr. L. Sammon of the Electrical Trades Union stated explicitly at the conference that his union would expect a demand for an interim wages increase if negotiations dragged on.

A debate on the question of arbitration – also the subject of comment by recent Courts of Inquiry – was very revealing. The proposal, supported by the two general workers' unions, that when in an industrial dispute negotiations with the workers broke down, union leaders should immediately seek the help of the Minister of Labour, met with considerable opposition on the ground that it would considerably weaken the union leaders in negotiations and result in smaller arbitration awards. With such an attitude to contend with, the executive of the Confederation will do well if they can bring the negotiations in which they are about to enter to a conclusion which is truly in the national interest.

* * *

PERSIAN OIL AGREEMENT

The recent agreement concluded between the Persian Government and the International consortium of oil companies who have taken over the management of the Persian oilfields and Abadan refinery from the Anglo-Iranian company may well lead to a substantial increase in the demand for British-made oilfield equipment. The most significant result of the agreement is the restoration of the Middle East as the major source of Sterling oil.

Anglo-Iranian have sold 60 per cent. of their holdings in Persian oil to seven companies who, with them, constitute the consortium (Compagnie Francaise des Pétroles, Gulf Oil, Royal Dutch, Shell Petroleum, Socony-Vacuum, Standard Oil of California and the Texas Company). Anglo-Iranian thus have the largest stake, but the legal title to ownership remains with the Persian Government. The new company structure of the industry is extremely complex, consisting of four companies, two registered in Persia (under Netherlands law) with minority Persian representation, and two registered in London. One of the Persian companies will operate the Abadan refinery and the other control production at the oilfields. The main London company will be a holding company for all shares of the operating companies, and the other will be concerned with obtaining supplies required by the operating companies.

There is little doubt that the consortium's requirements of new plant and equipment will be substantial, as nothing has been added or replaced since the industry was nationalised in 1951. No details have yet been released, however, concerning the location and management of the London supplies company. None of the parties to the agreement has cause for much dissatisfaction. Persia has been promised the sale of 68 million tons of crude oil and refined products over the next three years, and a 50 per cent. share in the profits arising from the sale. Anglo-Iranian will receive £25 millions from Persia over the next ten years, in compensation for oil assets in Northern Persia and for losses suffered since 1951. In addition, the company will be paid compensation – unofficially estimated at £200 millions – by the other members of the international oil consortium.

* * *

MOVING PAVEMENT

A conveyor belt designed to carry passengers from one train to another at interchange stations has been developed in the United States by the Goodyear Tyre and Rubber Company, who make the belt, and the Stephen Adamson Manufacturing Company, who build the machinery. The first "Speedwalk" installation has been opened in the Erie station of the Hudson and Manhattan Railroad in Jersey City, N.J. The main purpose is to make the station more attractive by increasing the comfort of travellers (they can place their heavy baggage on the conveyor), and to reduce the time needed to change trains at peak hours.

The Speedwalk consists of a 460-ft. endless rubber and fabric belt, 5½ ft. wide and ⅝ in. thick, riding on a bed of closely-spaced steel rollers. Power is supplied by a 20-h.p. electric motor. The belt moves at a speed of 120 ft. a minute – just under 1½ m.p.h. – and has a capacity of 10,800 passengers an hour. As most travellers walk while on the belt, the capacity is probably much greater. The Hudson and Manhattan Railroad hope that the investment in the sidewalk – 75,000 dols. – will result in an increase in traffic. The Transit Authority of New York City recently announced that plans to install a moving-belt subway to replace an out-of-date shuttle line are almost complete, and that construction is likely to start at the end of this year. Similar conveyor plants could clearly be adopted in airports, "supermarkets" (the American name for self-service stores) sports stadiums and city subway systems. Such developments will doubtless be watched with interest by British Railways and London Transport. Moving pavements would seem particularly suitable for use in underground stations serving main-line stations, where many passengers carry luggage and no porters are available.

* * *

BRITISH ENTERPRISE IN U.S.

In an age when the United States has become the chief provider of investment capital in the world, and American enterprise has been rapidly expanding manufacturing capacity within the United Kingdom, it comes as something of a surprise to be reminded that some British investment is still being undertaken in the United States. Most if it has certainly been on a fairly small scale, but not so that of the Bowater organisation whose pulp and paper mills which lately went into production at Calhoun in Eastern Tennessee have cost over £20 millions. (60 million dols.). The Bowater Paper Corporation subscribed the entire equity capital of 15 million dols. while the remainder of the capital was obtained from United States sources.

The new mills, which will have an initial capacity of 130,000 tons of newsprint and

55,000 tons of kraft pulp annually, are not the largest owned by the Bowater Corporation, but have proved to be the most expensive. A high return to the United Kingdom in dollar earnings, however, seems assured. The entire newsprint production for the next fifteen years has been purchased under long-term contracts by publishers in the Southern States (the annual output of 55,000 tons of pulp, on the other hand, will be exported to Bowater mills in the United Kingdom and paid for in dollars in the normal way). Under a Certificate of Necessity granted for newsprint under the defence programme of the United States Government, the Bowater Corporation will be able to write off 45 per cent. of the capital cost of the new mills against taxable profits over the first five years of operation. The mills will make an important contribution to the life of Eastern Tennessee by paying out 3·5 million dols. in wages annually and a further 3·5 million dols. in payment for local purchases of pulp wood. The Bowater organisation already owns 200,000 acres of forest land in Tennessee and adjoining States, and is undertaking a large re-afforestation programme under which they hope to have planted 10 million pine seedlings by the end of 1954.

It seems possible that the new mills will eventually be expanded though no plans have yet been announced. World demand for newsprint is still not being fully satisfied.

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HEAVY ROAD VEHICLES

The assessment of heavy-vehicle prospects by the directors of E.R.F. (Holdings), Limited, last week on the occasion of their £250,000 5½ per cent. debenture stock 1969/79 issue was more cautious than the heavy commercial-vehicle production statistics would seem to warrant. In their view the record profits made by the operating company in recent years "should not be taken as a guide to the future; moreover competition is increasing." E.R.F. profits for the current financial year, ending March 31, 1955, are estimated at £150,000, 10 per cent. less than those of the last financial year and 37 per cent. below the 1952 post-war peak.

Output of commercial vehicles of over 6-tons carrying capacity during the first half of 1954 totalled 10,459 vehicles, compared with 8,542 in the corresponding period of 1953, an increase of 22½ per cent. The corresponding figures for the output of public-service vehicles were 4,525 and 3,743, an increase of over 20 per cent. The recovery that began in 1953 appears, therefore, to have been well maintained. These figures do not, however, necessarily reflect the true position of heavy-vehicle builders, as they include the production of lorries of over 6 tons and buses by car manufacturers, who have tended over the last two to three years to raise the pay-load range of their vehicles, the unladen weight of which is subtantially lower than that of typically heavy lorries of the E.R.F. or Leyland type. For example, the unladen weight of a Vauxhall 7-ton lorry is approximately 2·3 tons, compared with about 3·2 tons for the Leyland Comet, in the same load-capacity range. There has been a considerable increase in the past three years in the output of the "light type" of 7-ton lorries which are manufactured by Vauxhall, Rootes and Dodge. The output of these vehicles is estimated to have risen from about 5,800 in the first 6 months of 1953, to 7,000 in the first 6 months of this year, when they accounted for over two-thirds of total vehicle production over 6-ton load capacity. Demand for the light-type 7-ton vehicle is believed to be greatly in excess of supply and it would not be surprising if other car manufacturers came into the field in the near future. Output of buses by car manufacturers was nearly 50 per cent. higher in the first half of this year than in the first 6 months of 1953, whereas total output of public service vehicles rose by only 20 per cent.

These trends towards an increase in the proportion of the light type of vehicle over 6 tons is doubtless the increased competition to which directors of E.R.F. have in mind. There is, however, on the basis of current output figures, little reason to expect a fall in the output of "heavy type" lorries this year. So far the heavy lorry builders have shared in the present boom in roughly the same proportion: output of both types in the first 6 months of the year is about 22 per cent. above the figures for the first half of 1953. Demand shows no sign of flagging, and exports have increased considerably.

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WAGON BUILDERS – AMERICAN AND BRITISH

American railway-wagon builders are short of work. Output of wagons fell from 112,640 in 1948 – the post war peak – to 81,000 in 1953, and the fall has continued this year. Private builders are getting less and less of the business available. In 1948, railway companies and privately-operated railway lines, such as the Fruit Growers Express, built just over a quarter of their own needs; in 1953, they built 34 per cent. of the total, leaving less than 65,000 for the private builders. There is little prospect of improvements in demand. Statistics published by the American Railcar Institute show that 18 per cent. of the 1·7 million wagons in Class I railways are over 30 years old (only 20 per cent. are less than 5 years old), but no major technical improvements in design have taken place over a long period and wagons are therefore scrapped only when they are unfit for repair. In this instance the American policy is to rebuild rather than replace. The impact of falling demand on the industry has led to a sharp contraction of capacity. The Pressed Steel Car Corporation, who began building wagons in 1899, have closed their last workshop in Mt. Vernon; Westinghouse Electric Corporation sold their interests to Baldwin-Lima-Hamilton Corporation and are no longer builders of rolling stock; American Car and Foundry Company have changed their name to A.C.F. Industries Inc. to fit in with their widely diversified manufacturing activities.

The trend in this country is much more hopeful at present. The British Transport Commission agreed to the steel industry's suggestion earlier this year that wagons carrying iron ore should be replaced by larger wagons with a carrying capacity of 27 tons (for unloading by tipplers) or 25½ tons (for bottom discharge). All existing 16-ton and 22-ton wagons will eventually be replaced. It has also been the "settled policy" of British Railways since 1951 that a 24½-ton capacity coal wagon should be introduced as soon as possible. Only about 600 of these have been placed in service so far, and about two thirds of the 600,000 mineral wagons at present in use are of 14-ton capacity. The war-time decision to standardise on 16-ton wagons, based on the type of loading facilities available at pit-heads, will defer for many years the standardisation on 24½-ton wagons, but the substantial economies possible through their use are likely to ensure continuing business for British wagon builders. Recent contracts placed for 35,000 16-ton wagons for delivery during the next four to five years, which will build up a block of some 300,000 16-tonners with a useful life of 30 to 40 years, will make easier the gradual adaptation of pit-head machinery and plant to take the 24½-tonners (estimated to cost up to £100,000 at each pit).

Output during 1953 was the highest since the war and about 75 per cent. greater than pre-war. Output in the first quarter of this year was nearly one-quarter above the first quarter of 1953, though exports were 5 per cent. lower.

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U.S. GOVERNMENT HELPS SHIPBUILDERS

President Eisenhower's announcement last week that "the recent decline in economic activity has come to a halt" may have been optimistic, but his hope that the economic programme now being enacted by Congress would stimulate enterprise and development "in all directions" has already proved well founded. The shipbuilding industry is one of the first to benefit. A recent announcement told that the industry's work on hand or on order had declined to less than 300,000 tons in July, and that no new orders had been booked during the past 18 months. The Administration now expects that 400 million dols. (148 millions) will be spent on new merchant ship building as a result of a series of Bills enacted by Congress. Of this, 188 million dols. will come from Government funds, and somewhat more will be contributed from private sources. Included in the new construction programme are four passenger liners which are expected to cost 95 million dols., nearly half being provided by the United States Government in construction differential subsidies and allowances for national defence features. Tankers figure prominently in the programme, despite the present state of redundant tanker tonnage (Weekly Survey, ENGINEERING, July 9, 1954). The United States Navy will order five of the thirty 25,000-ton tankers projected and fifteen will be ordered by private companies who will receive ten-year charters from the Navy under the terms of the new legislation. Ten more will be built for private companies as a result of new legislation which authorises the Government to use 26 million dols. to purchase twenty ten-year-old tankers from operators who undertake to use the proceeds as part-payment on new vessels. The United States Navy will also spend 50 million dols. on the purchase of special-type freighters, tankers and troop transports, some specially designed to service Arctic air bases. Congress also intend that ship-repairers and converters shall be kept busy. An experiment to convert Liberty ships, which involves lengthening and strengthening the hulls and installing new propulsion machinery, will cost 11 million dols., and 18 million dols. will be spent on repairs to ships that are to be laid up as part of a strategic reserve.

An interesting feature of the Administration's plans to help shipbuilders is a provision to allow the Government to insure ship mortgages held by private lending agencies up to 90 per cent. on the principal and 100 per cent. on the interest. In some cases, for vessels certified as essential to national defence, insurance will be allowed for 100 per cent. of the principal. The Mortgage Insurance Bill will make it possible for coastal shipping companies, whose business has been depressed since the war, to obtain finance, and several have plans to revive traffic through the use of new types of ships able to carry loaded freight cars and lorries, thereby reducing heavy-cargo handling costs in ports.

This assistance by the United States Government to the shipbuilding industry, prompted mainly by political considerations in an election year, will almost certainly bring it prosperity when all hope of a revival seemed lost.

PERSONAL

MR. K. L. STRETCH, M.A.(Cantab.), A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., barrister-at-law, has been appointed works manager at Calder Hall, Sellafield, Cumberland, where this country's first atomic power station is now under construction. Since December, 1951, Mr. Stretch has been design engineer, Salt Division, I.C.I. Ltd.

MR. W. R. J. COOK, C.B., M.Sc., Chief of the Royal Naval Scientific Service, has been released from his present post to take up that of deputy director, Atomic Weapons Research Establishment, Aldermaston, of which the director is SIR WILLIAM PENNEY.

SIR JOHN GREAVES has decided to relinquish his position as managing director of Davey, Paxman & Co. Ltd., Standard Ironworks, Colchester, on September 30. Although Sir John is to continue as a director of Ruston & Hornsby Ltd., he is retiring from the board of Davey, Paxman & Co. Ltd. MR. G. W. BONE, M.I.Mech.E., A.F.R.Ae.S., assistant managing director, Davey, Paxman & Co., has been appointed to succeed Sir John as managing director.

MR. J. F. B. JACKSON, B.Sc., A.R.I.C., F.I.M., has relinquished his position as director of the British Steel Castings Research Association in order to take up the appointment of director in charge of the new foundries of A.P.V.-Paramount Ltd., Crawley, Sussex, producing castings in special steels and non-ferrous metal alloys.

MR. F. G. BURLAND, who has been in charge of the permanent-way design section of the London Transport Executive, 55 Broadway, S.W.1, since 1939, is retiring this month.

DR. C. J. MACKENZIE, C.M.G., M.C., F.R.S., has been awarded the 1954 R. B. Bennett Empire Prize of 100 guineas of the Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. Founded in 1945 by the late Viscount Bennett, the prize is awarded every three years for outstanding contributions to the promotion of the arts, agriculture, industries and commerce of the overseas empire. Previous recipients have been (1945) DR. CHARLES CAMSELL, C.M.G. (Canada); (1948) SIR FRANK STOCKDALE, G.C.M.G., C.B.E. (Great Britain); and (1951) DR. (now SIR) BRUCE LEVY, O.B.E. (New Zealand).

MR. W. H. DANN, M.B.E., B.Sc., Wh.Sch., A.M.I.N.A., has been appointed to the board of directors of Saunders-Roe (Anglesey) Ltd., Beaumaris, Anglesey.

MR. ROBERT ATKINSON, D.S.C., R.D., B.Sc., M.I.Mar.E., has been elected to the board of directors of the Hamworthy Engineering Co., Ltd., Poole, Dorset, and of British Combustion Equipment Ltd. DR. N. A. CHEETHAM, B.Sc., has been appointed chief engineer of British Combustion Equipment Ltd.

MR. W. T. COX has retired from the position of chief engineer of No. 4 (Cumberland) area, Northern (Northumberland and Cumberland) Division, National Coal Board. He has been succeeded by MR. J. B. TINDALE.

MR. E. P. B. METCALFE has been appointed engineer-in-charge of the new television transmitting station of the British Broadcasting Corporation now under construction at Rowridge, Isle of Wight. The station will come into service on November 12.

MR. F. W. WHITING, B.Sc.(Eng.), A.M.I.E.E., has been appointed manager of the Nottingham area branch of the Lancashire Dynamo Group, as from September 1.

COMMANDER F. W. N. BASSETT, R.N.(ret.), formerly director and commercial manager, Normalair Ltd., Yeovil, has been appointed commercial director. MR. D. C. COLLINS, formerly a director, is now to be works director, and MR. W. OPPENHEIMER, formerly financial adviser, has been made finance director of the firm.

MR. C. E. SLADE, M.Inst.W., has left the service of Philips Electrical Ltd. and has started a practice as a consulting engineer specialising in resistance welding. His address is: 11 Trowlock-avenue, Teddington, Middlesex.

MR. ERNEST HAUGHTON, A.M.I.Mech.E., who joined the engineering staff of the Corporation of Liverpool in 1948, has been appointed assistant city engineer (mechanical) to the Corporation.

PROFESSOR J. P. DEN HARTOG, who has been in charge of the division of applied mechanics of the Department of Mechanical Engineering at the Massachusetts Institute of Technology, Cambridge, Massachusetts, U.S.A., since 1945, has now been appointed head of that Department.

MR. G. E. RATCLIFFE has joined the Wallace Attwood Co., Chantrey House, Eccleston-street, London, S.W.1, as a consultant.

MR. J. A. BALDRY has been appointed assistant sales manager of the Lamson Engineering Co., Ltd., 6-8 Hythe-road, Willesden Junction, London, N.W.10.

MR. G. E. HUGHES-JONES, who joined the Brush Electrical Engineering Co. Ltd., Loughborough, Leicestershire, on the staff of their office in Leeds in the autumn of 1953, has now been appointed manager of the company's office in Newcastle-upon-Tyne. Mr. Hughes-Jones took up his new responsibilities on August 14.

* * *

BUSINESS CHANGES

THOS. STOREY (ENGINEERS) LTD., Abbey House, Victoria-street, London, S.W.1, have been appointed sole agents in the British Isles for Lorain equipment, the products of the Thew Shovel Company, of Lorain, Ohio, U.S.A.

A. G. WILD & CO. LTD., manufacturers of railway-coach fittings and colliery equipment, Sheffield, have opened a new London office at 7 Victoria-street, S.W.1. (Telephone: ABBey 6761.) The manager of the office is MR. B. G. V. FORMAN.

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GRAND PRIX RACING CAR

British Competitor for the Formula I Class

The illustration below shows the new 2½-litre Formula I racing car which has been developed by Connaught Engineering, Send, Surrey. The car was tried out on the Goodwood track for the first time on August 12, by Mr. Rodney Clarke, its designer.

The car has a tubular welded chassis, with independent front suspension and de Dion type (with torsion bars) at the rear. Wire wheels are used with Alfin brake drums. It has a four-cylinder Alta engine with a capacity of 2,470 c.c.; bore and stroke are 93·5 mm. and 90 mm. respectively. The compression ratio is 12½ to 1 and the maximum engine speed in the region of 7,000 r.p.m. S.U. fuel-injection equipment is used. The shaft from the engine to the gear box has Hardy Spicer couplings while the final drive uses a Layrub unit. An Armstrong-Siddeley gear box is fitted with the pre-selector remote from the engine; the lever is on the right of the steering column. There is a Connaught double-reduction back-axle drive.

This, the prototype car, has a streamline body which is to be tested in a wind tunnel. Some later models will have "monoposto" bodies. The driver sits about 18in. further forward than in the Mercedes, with his legs on each side of the engine. The steering uses a rack-and-pinion system. On the trial runs a speed of 100 m.p.h. was exceeded, but no attempt was made to force the pace though it is hoped that over 170 m.p.h. may eventually be attained on a suitable course. An extensive series of trials will be carried out before any serious racing will be undertaken.

COAL MINING IN KOREA

Technical Assistance by Powell Duffryn

Powell Duffryn Technical Services, Limited, the technical subsidiary of Powell Duffryn, Limited, 19 Berkeley-street, London, W.1, has been appointed to provide advisory teams to assist in the rehabilitation of the coal-mining industry in the Republic of Korea, as part of the extensive re-development programme of the United Nations Korean Reconstruction Agency. This arrangement has the approval of the Agency, which is an organisation set up by the United Nations to assist the country's rehabilitation. Coal mines in the Republic of Korea are controlled by the Dai Han Coal Corporation, a Government-owned body.

The contract was secured at Seoul in the face of strong international competition and the work involved is expected to take at least two years to complete. The full-time services of not less than twelve British specialists in the various phases of coal-mining and ancillary operations will be required.

Among the duties to be undertaken will be the giving of advice and assistance to the Dai Han Coal Corporation on a long-term basis, but there is no provision for any investment by the Powell Duffryn companies in the Corporation's properties.

* * *

WORK STUDY AND PLANT MAINTENANCE

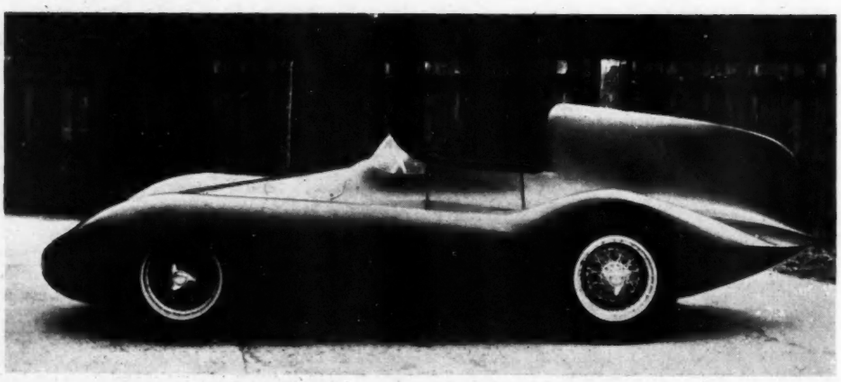
Week-end London Conference Planned

Arrangements have been made by the Society of Industrial Engineers to hold a second conference on "Work Study and Planning Applied to Plant Maintenance" at St. Ermin's Hotel, Caxton-street, London, S.W.1, from 6 p.m. on Friday, October 29, to 10 p.m. on Saturday, October 30.

This second conference is intended to provide opportunities for engineers and administrators to discuss problems of work study applied to plant maintenance with practitioners who have successfully employed such methods for several years.

Discussions will take place on the planning and organisation of work, method study, work measurement, analytical estimating, incentives, and costing. A fee of six guineas, to include the cost of certain meals, will be payable by persons attending the meeting. Arrangements for sleeping accommodation may be made direct with St. Ermin's Hotel.

Applications to attend should be made to the honorary education officer, the Society of Industrial Engineers, 28 Victoria-street, London, S.W.1.



The Connaught racing-car with a 2½-litre Alta engine.

Obituary

MR. F. E. J. OCKENDEN

Authority on Electrical Measurements

We regret to record the death of Mr. F. E. J. Ockenden, which occurred at Melbourne, Australia, on Saturday, July 31, in his 61st year. He was well known among electrical engineers for his work on measurements and on the development of instruments.

Francis Edmund Jury Ockenden was born in London on September 10, 1893, and was educated at Clapham Secondary School and the Battersea Polytechnic, where he obtained a diploma in electrical engineering. From September, 1913, to July, 1914, he was engaged in a junior position with Siemens Brothers and Company, Limited, Woolwich, but was mobilised as a Territorial on the outbreak of war and served with the London Electrical Engineers, Royal Engineers, until March, 1919.

On his release from the forces, Ockenden joined Everett, Edgcumbe and Company, Limited, as test-room assistant and three years later was placed in charge of research on the company's products under the supervision of Colonel Kenelm Edgcumbe (now the Earl of Mount Edgcumbe). In 1929 he was made adviser to the directors on all technical questions and in 1934 joined the board as chief research and development engineer. In this position he was responsible for all the firm's research work. In 1948 he went to Australia as adviser to Watson, Victor, Limited, who are Everett, Edgcumbe's agents for the Dominion.

Ockenden was elected an Associate Member of the Institution of Electrical Engineers in 1928 and was transferred to the class of member ten years later. He served on the council from 1935 to 1938 and was chairman of the (then) Meter and Instrument Section in 1939-40. He was appointed the Oversea Representative of the Council for Victoria and Tasmania in 1951 and was chairman of the Victoria and Tasmania Committee from 1952 to 1954. He had contributed more than once to the *Proceedings* of the Institution and was awarded the Ayrton Premium (jointly with Lord Mount Edgcumbe) in 1927 for a paper on "Recent Advances in Alternating-Current Measuring Instruments." He was also a Fellow of the Institute of Physics and had read a number of papers before them.

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MR. JOHN P. TAYLOR

Late Editor of "Shipbuilding and Shipping Record"

It is with keen regret that we record the death on August 8, at Sudbury, Suffolk, of Mr. John P. Taylor, hardly more than a year after he had retired from the editorship of our contemporary *Shipbuilding and Shipping Record*, a position which he had occupied with distinction for 40 years. Mr. Taylor, who was 71 years of age, had been in indifferent health for some time, but it was not generally appreciated that his condition was so serious as it proved to be.

John Percy Taylor, or "J.P.," as he was known to an exceptionally wide circle of friends in shipping and in technical journalism, was born in Bishopwearmouth, Sunderland, where he received his schooling and remained until early manhood. He grew up in an atmosphere of shipping, for his father was master of a succession of colliers, trading between the North-East Coast and the Thames, before being appointed a Trinity House pilot, and "J.P.," in his youth, had made that passage many times. His own early ambition, however, was to be a doctor; but family circumstances prevented its achievement and he was apprenticed to a pharmaceutical chemist in his native town, eventually qualifying as one himself. Even so, he was in constant contact with ships and shipping men, for his employer had a considerable connection in the supply and replenishment of ships' medicine chests and it was part of young Taylor's duties to visit the ships with the necessary medical supplies.

He went into journalism as assistant editor of a pharmaceutical journal, but when, in 1913, the *Shipbuilding and Shipping Record* was founded, he seized the opportunity to resume a closer connection with the world of shipping. His application for the post of editor was accepted, and in it he really found his *métier*. The outbreak of war, when the new periodical was only 16 months old, presented him with some difficult problems before it could be said to be firmly established, but his perseverance was eventually rewarded as it deserved to be. For many years past, no one was better known or more generally respected in every field of ship construction, repair and operation, both at home and abroad, as was evidenced by the complimentary dinner that was given in his honour by the Chamber of Shipping on his retirement a little more than twelve months ago.

Mr. Taylor was an Associate of the Institution of Naval Architects, a Fellow of the Institution of Journalists, and a past President of the Anchorites – the shipping club which, in its specialised sphere, confers its own peculiar distinction. Latterly, he had been acting as chairman of the Press advisory committee which was set up in connection with the successful effort to raise a fund of £250,000 to preserve the famous tea clipper, the Cutty Sark. As an editor, whether of current material, week by week, or in the exacting task of revising the annual *Directory of Shipowners, Shipbuilders and Marine Engineers*, he displayed always a clear judgment and a sound appraisal of the often varying circumstances of the shipping industry, combined with a gift for straightforward factual composition which was well exemplified in the little book, *The Ship You Will Command*, in which he set out, for the benefit of the youth with leanings towards the sea, what a seafaring life has to offer under present-day conditions.

* * *

We regret also to record the deaths of the following:

MR. WILLIAM JOHN ORANGE, in Calcutta, on August 2, at the age of 53. He was general manager for India of the English Electric Co. Ltd., having been appointed to that position in December, 1935. He was apprenticed with Lancashire Dynamo and Crypto Ltd., and served them for 17 years, finally as manager for India and Burma.

MR. CHARLES AUGUSTUS CARLOW, D.L., Hon. LL.D., M.I.C.E., M.I.Min.E., F.R.S.E., at his home in St. Andrews, Fife, on August 13, at the age of 75. He took office as President, Institution of Mining Engineers, in February, 1937. He was managing director of the Fife Coal Co. Ltd., Leven, Fife, from 1917 until 1939, and chairman and managing director, from 1939 until 1952. We hope to publish a more detailed obituary note on Mr. Carlow in our next issue.

DR. HUGO ECKENER, at Friedrichshafen, Germany, on August 14, at the age of 86. He was a partner of the late Count Zeppelin and designed numerous rigid airships, among them the Graf Zeppelin which was completed in 1928 and subsequently made many long-distance flights.

MR. LEON SAFRAZYAN, announced in Moscow on August 15, at the age of 61. Deputy Minister of the oil industry of the U.S.S.R. since 1949. He was responsible for the construction of the Chelyabinsk tractor plant and the Yaroslav and Gorky motor-car works.

Letters to the Editor

MOLYBDENUM DISULPHIDE

Comparison with Graphite as a Lubricant

SIR, I have read with interest the article on molybdenum disulphide which appears in page 171 of the issue of your journal, August 6. Particular emphasis is placed on the strong molecular bond which is formed between molybdenum disulphide and the metallic surfaces with which it comes into contact, and the author goes on to state "unlike graphite, the layer only builds up to a certain thickness, so that it is difficult to over-lubricate."

This statement requires qualification, as in its present form it is misleading. The molecular bond formed between molybdenum disulphide and a metallic surface is due to the free energy which exists at the clean surface of a metal and which accounts for the adsorption to the surface of the minute plate-like particles of molybdenum disulphide. While the adsorbed film may consist of a number of particles of molybdenum disulphide superimposed one upon the other, the thickness is controlled by the relatively weak van der Waals forces between adjacent layers and the tangential pressure applied to the outermost particles.

Since graphite has a crystal lattice structure similar to that of molybdenum disulphide, the same phenomenon exists when graphite is used as a lubricant. To suggest, therefore, that graphite builds up on the surface beyond a certain thickness, to result in over-lubrication, is untrue. Several years go Jenkins, Finch and Wilman confirmed by electron-diffraction examination, the presence of the "graphoid surface" formed by the adsorption of colloidal graphite to a metallic base.

Graphite in powder form, and also colloidally dispersed in a variety of carrier liquids, has been employed as a lubricant for a much longer period than has molybdenum disulphide.

While in many lubrication applications the presence of an adsorbed layer of solid lubricant is adequate for the purpose, there are instances in industry where a layer of colloidal graphite or colloidal molybdenum disulphide of certain thickness is desirable. It can be stated that for many years leading industrial organisations in the United Kingdom, America and other overseas countries, have made a practice of pretreating bearing surfaces of engine and machine components with colloidal graphite or colloidal molybdenum disulphide, the film being bonded to the surface by means of resin which is incorporated in the colloidal dispersion.

Such films of solid lubricant play an important part in preventing scuffing and scoring of finely machined surfaces during the initial running-in period and are to-day considered to be equally as important as adsorbed films, the formation of which with colloidal graphite was first investigated by Dr. E. G. Acheson about 50 years ago.

Yours faithfully,

F. GORDON KAY,
Sales Manager.

Acheson Colloids, Limited,
18 Pall Mall, London, S.W.1.
August 10, 1954.

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R.E.M.E. OFFICERS' DINNER

The annual dinner for serving and former R.E.M.E. officers is to be held on Friday, October 29, at the Connaught Rooms, Great Queen-street, London, W.C.1. Tickets, price 22*s.* 6*d.*, can be obtained from the secretary, R.E.M.E. Dinner Committee, Room C505, War Office, Chessington, Surrey.

CONTRACTS

Jet Fighter Aircraft. Negotiations have been completed recently between the Danish Government and HAWKER AIRCRAFT LTD. for the supply of the firm's Hunter supersonic jet fighter aeroplanes to the value of £3 millions. Shortly after, a second large contract for the swept wing Hawker Hunters was announced. This second order, which is from the Swedish Government, is valued at £12 millions.

Radar Equipment. MARCONI'S WIRELESS TELEGRAPH CO. LTD., Chelmsford, Essex, have obtained a contract, from the Egyptian Government, for the supply of navigational radar equipment, radio transmitters, receivers and associated equipment for use on board five warships of the Egyptian Navy, namely, the Tarek, Aboukir, Damietta, Rashid and Ibrahim. Each ship is to have an installation consisting of one of the firm's Radiolocator IV and a Transarctic transmitter-receiver. In addition, eight communications receivers will be supplied for allocation among the ships.

Permanent-Way Materials. A contract for the supply of permanent-way materials to the value of £5 million, has been signed between THE UNITED STEEL COMPANIES LTD., 17 Westbourne-road, Sheffield, 10, and the Seven-Year-Plan Organisation in Persia. The contract calls for the delivery, over three years, of 100,000 tons of rails and 4,000 tons of fishplates, fish-bolts, washers and turn-outs.

Drainage and Irrigation Works. A 5-year contract for works connected with the drainage and irrigation of an area of 129,763 acres in British Guiana has been awarded by the British Guiana Government, with the assent of the Colonial Office, to SIR LINDSAY PARKINSON & CO. LTD. The contract, which is valued at approximately 6 million dols., is called the Boerasirie Extension Scheme and involves the excavation of approximately 8¼ million cub. yds. of earth in 36 miles of conservancy dam, and 1,310 miles of canals and drainage trenches. By the time the work is finished the contractors will also have built some 152 large and small reinforced-concrete headworks, sluices, bridges and similar installations. When the scheme is completed it is anticipated that all farmers on the coastlands between the Essequibo and Demerera Rivers should be able to cultivate their holdings without fear of flooding during rainy weather, or lack of water during periods of drought.

Viscount Air Liners. An order has been placed by Central African Airways, the national air line for the Federation of Rhodesia and Nyasaland, with VICKERS-ARMSTRONGS LTD., Vickers House, Broadway, Westminster, London, S.W.1, for five Vickers Viscount 700 D air liners. These are a new improved version of the Viscount aircraft fitted with 1,550-h.p. Dart engines, and it is hoped that they will be operating over Central African routes early in 1956.

Power Station and Transmission-Line Equipment. Contracts have been placed by the British Electricity Authority during July for power-station and transmission-line equipment, amounting in the aggregate to £3,566,800. The principal contracts include, for Acton Lane "B" power station, Willesden: two 240,000 lb. per hour boilers, with MITCHELL ENGINEERING LTD.; for Castle Donnington power station, near Derby: high-pressure pipe work and valves, with AITON & CO. LTD.; and ash and dust-handling plant, with BABCOCK AND WILCOX LTD.; for Willington "A" power station, near Derby: a 830,000 lb. per hour boiler, with INTERNATIONAL COMBUSTION LTD., and circulating water valves, with J. BLAKEBOROUGH & SONS, LTD.; for Lincoln power station: two 25-MVA generator transformers, with CROMPTON PARKINSON LTD.; for Nottingham power station: high-pressure pipe work and valves, with AITON & CO. LTD.; for Mexborough power station, Yorkshire: civil engineering works, with ROBERT M. DOUGLAS (CONTRACTORS) LTD.; for Barony power station, Ayr: coal-handling plant, with BABCOCK AND WILCOX LTD.; and 275-kV overhead lines, from Stella West to Blyth, with BRITISH INSULATED CALLENDER'S CONSTRUCTION CO. LTD.

Turbo-Alternator Sets. Negotiations have been completed by the ENGLISH ELECTRIC CO. LTD., with Preece, Cardew and Rider, consulting engineers, acting on behalf of the Municipal Council of Georgetown, Penang, Federation of Malaya, for the supply of two 10,000-kW, 11-kV turbo-alternator sets, designed to operate at a steam pressure of 400 lb. per square inch and a temperature of 800 deg. F., with condensers and feed-heating equipment. These sets are for a new power station, on Penang Island, to replace the Council's old one at Prai, on the mainland.

WOODEN RAILWAY SLEEPERS

ADVANTAGES OF CONVENTIONAL MATERIALS

In an age of constant introduction of new materials, and the progressive improvement of existing ones, it is sometimes interesting to examine the continued use, without change, of one material for year after year. One important example is wood, which has always been the traditional material used by British Railways for track and crossing sleepers. Railway permanent-way engineers have had, perforce, to use small quantities of steel and concrete sleepers in times of national emergency, as in the second World War, but they have reverted to the use of timber immediately Government regulations permitted.

Wood has the virtues of economy in cost in comparison with other materials, and ease of transport, handling and installation; it is also favoured by permanent-way engineers for its resilience and long life – an average of about 20 years on main-line track, plus a further ten years on sidings after subjection to preservative treatment. Even after these periods, wooden sleepers have a further value for use as temporary roadways, revetments, storage bins for coal and ballast, and finally as firewood.

UNITED KINGDOM SUPPLIES

Although certain small quantities of other species were used experimentally during the last war, the traditional species are Baltic redwood and Douglas fir, and these have, of course, to be imported from countries abroad. Most of the imports are softwood sleepers, only relatively small quantities of hardwood sleepers, such as Australian Jarrah, being used by the London Underground railway system because of its high fire resistance and non-decaying properties in damp conditions. Moreover, the use of this more expensive wood, with its longer life and consequent less frequent need for replacement, is an important factor when it is remembered that only about three hours are available in the early hours of the morning for permanent-way staff to effect repairs, and that this work has to be carried out in the confined conditions of the underground tunnels.

In 1938, the largest quantity – 40,500 standards of 165 cub. ft. each (35 per cent.) – came from Poland, followed by the Soviet Union and Baltic States with 30,300 standards (26 per cent.), Canada, 29,300 standards (25 per cent.), and Yugoslavia, 5,000 standards (4 per cent.). Last year, Canada with 25,686 standards (45 per cent.), and France, 24,791 standards (43 per cent.), supplied the bulk, the only other quantity of any size being 4,500 standards (8 per cent.) from the United States of America. In 1938, 117,211 standards, having a value of £1,966,507, were imported, at an average cost of £16·75 per standard, compared with less than half that quantity in 1953, 56,829 standards valued at £4,282,558 at an average cost of £75·3 per standard.

In the years 1930-1939 the imports of wooden sleepers averaged nearly 100,000 standards per year; this was reduced to just over 34,000 standards annually during the war years (1940-1945) owing to the demands on shipping space for war purposes, and the cessation of supplies from the Baltic region. It will be seen, therefore, that the 56,800 standards arriving last year were only a little over half the normal quantity arriving in pre-war years.

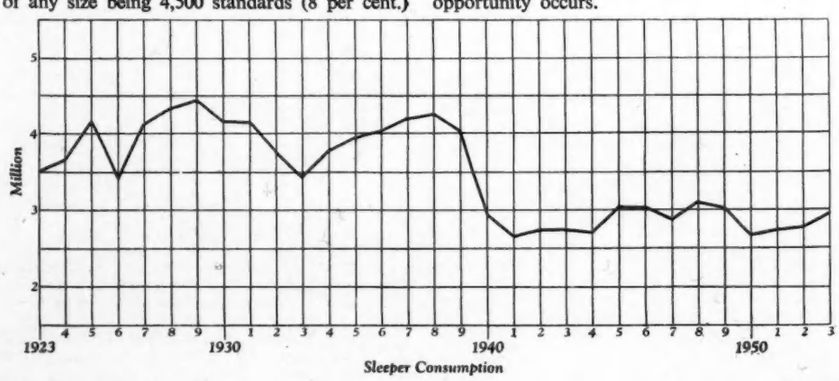
CONSUMPTION BY BRITISH RAILWAYS

The bulk of the sleepers are, of course, used by British Railways, only relatively small quantities being required for private works sidings and collieries, etc. From 1923 to date, British Railways used over 3,650,000 sleepers per annum, each containing 3 cub. ft. of timber, while during the war years (1940-1945) the average dropped to 2,825,000 each year. Some of the deficiency was met during this period by the substitution of home-produced concrete sleepers, but their use has been curtailed to some extent with the return of more normal conditions, mainly on such grounds as lower resiliency, difficulty in handling owing to weight, and cost, which has been considerably higher than the wooden ones.

About 2¾ million new wooden sleepers were laid in 1947, the figures jumping to over 4 million in each of the years 1948-1950 owing to the considerable arrears of track maintenance following the very heavy use made of the railways during the war. The number of wooden and concrete sleepers put into service in the past three years were:—

—	1951	1952	1953
Wood	3,748,000	3,781,000	3,956,000
Concrete	356,000	304,000	256,000

The total number of railway sleepers in use by British Railways at the present time is approximately 110 million, of which 108 million are wood and 2 million concrete. A comparatively small number of steel sleepers are also in use, but these are being withdrawn from service as opportunity occurs.



(2230) "ENGINEERING"

In the last 30 years the annual consumption of wooden railway sleepers by British Railways has varied between 2·65 and 4·5 million.

A LARGE HYDRO-ELECTRIC AND METALLURGICAL SCHEME

PLANS FOR NORTH-WEST CANADA

A scheme which is being undertaken by North-west Power Industries, Limited (a subsidiary of Quebec Metallurgical Industries, Limited) and Frobisher, Limited (a subsidiary of Ventures, Limited), has as its object the utilisation of the water power and metallurgical resources of northern British Columbia and the Yukon territory.

The hydro-electric portion of this scheme will, as shown on the accompanying map, employ the resources of the upper drainage system of the Yukon river, as well as those from other watersheds to the west and east of the upper Yukon valley. A group of lakes, which form the head waters of the river, will be used as reservoirs, while the flow of the river itself and its adjacent tributaries will be diverted to the valleys south of the Atlin lake. This water will be utilised in power houses in the Sloko, Nakonake and Taku valleys and will eventually be emptied into the Pacific south of Juneau in Alaska, the minimum flow being 28,000 cusecs. A later development will be the diversion of a portion of the water of the Alsek river, which now flows into the Pacific, into the River Yukon.

CIVIL ENGINEERING WORK

Of the three main dams which will form part of the initial storage scheme, one will be built four miles upstream from Whitehorse, another on the Teslin river, 40 miles north of Teslin lake, and the third near the confluence of the Yukon and Big Salmon rivers. The storage capacity provided by these dams, by a fourth near the point of confluence of the Taku and Inklin rivers and by the diversion of the water of the Dezadeash, or Upper Alsek, into the Takhini and Yukon, will enable nearly 5,000,000 h.p. to be developed.

From the Atlin lake, which lies at an elevation of 2,192 ft., two tunnels will carry the water to the Nakonake river just over 1,000 ft. below. The first of these tunnels will connect the Atlin and Sloko lakes and will be one mile long, while the other will be driven for 9·7 miles between the Sloko lake and the Nakonake valley. These works will enable a maximum of 2,800,000 h.p. to be generated, while a third tunnel which will be driven later between the Nakonake and Taku valleys, will bring the total power developed up to 4,300,000 h.p. It is estimated that 24,000 h.p. of this will be developed for construction purposes by 1956 and that 880,000 h.p. will be available for industry in 1962.

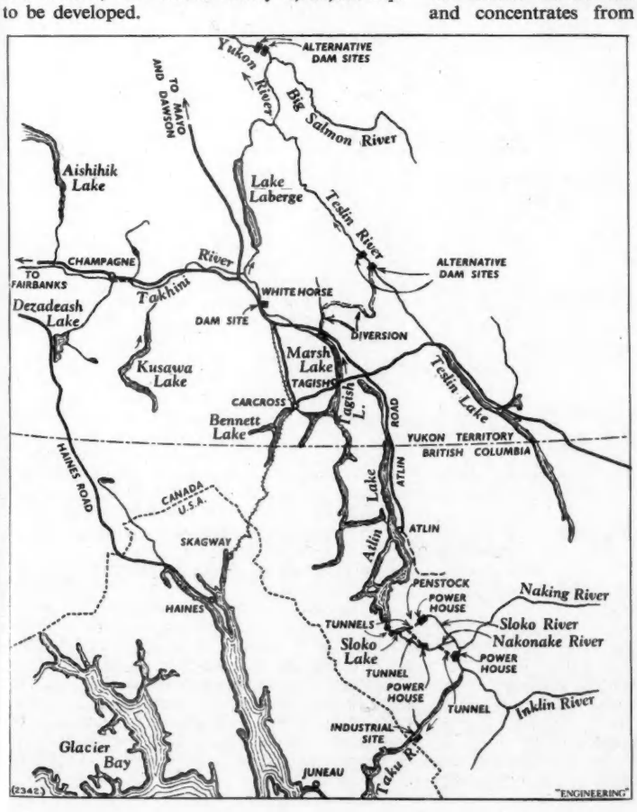
One of the sites proposed for the utilisation of this power is on the left bank of the Taku river in British Columbia, just east of the Canadian-Alaska frontier, as also shown on the map. The site will be connected to the power stations by 45-mile transmission lines, while raw ores and concentrates can be brought by barge from deep water up the Taku, a distance of 20 miles. In addition railway or road transport from Alaska would also be provided as the amount of ore required at the metallurgical centre increases. Alternatively, a deep-water industrial site further south on the coast of British Columbia could be adopted if the saving in the transport of raw materials compensated for the higher costs of transmitting power. For the present, however, Power Industries, Limited, are satisfied that the Taku site will meet their requirements.

METALLURGICAL ACTIVITIES

The major metallurgical operations at Taku will include the treatment of nickel-cobalt ores and concentrates from New Caledonia, the Philippines and other Pacific islands for the production of these two metals; the smelting of Pacific Coast iron ores and concentrates for the production of pig iron and steel; the production of ferro-manganese and silico-manganese from the ores of South West Africa; and the treatment of the zinc and other base metal concentrates available in the Pacific area of Canada.

To begin with, attention will be concentrated on the production of nickel, cobalt, iron, steel and manganese alloys, the range of activities being extended as successive blocks of power become available. It is estimated that the annual output of cobalt will increase from 1,020,000 lb. in 1956, to 3,720,000 lb. in 1962 and that of nickel from 480,000 lb. to 80,480,000 lb. during the same period. It is hoped that the output of iron and steel will rise from 35,000 tons to 210,000 tons during the same period and that by 1962 the production of manganese alloys will be 160,000 tons.

It is of interest to record that a profitable iron and steel industry could probably be established at or near the Northwest Power Project, as there are abundant deposits of ore at Zeballos on Vancouver Island, and on Texada Island and the Campbell River in British Columbia, as well as at Klukwan in south eastern Alaska.



Map of the area in British Columbia and Yukon territory where it is proposed to develop the hydro-electric potential and establish large ore-treatment plants.

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EXTENSION TO BOLD POWER STATION

The British Electricity Authority has received the consent of the Minister of Fuel and Power to the building of the second half of the Bold power station, near St. Helens, Lancashire. This authorisation covers the installation of three 60-MW sets, each of which will be served by a 550,000-lb. boiler. There will also be three cooling towers, each with an evaporative capacity of 2,250,000 gallons of water per hour. Finally, the station will have a capacity of 180 MW.

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ADVICE ON CORROSION PROBLEMS

Bureau to Deal with Queries

The British Iron and Steel Research Association has formed a Corrosion Advice Bureau in order to deal adequately with the numerous inquiries that are received on the prevention of corrosion.

The bureau will be located at 140 Battersea Park-road, London, S.W.11 (Tel. Macaulay 5511). J. C. Hudson, D.Sc., D.I.C., A.R.C.S., F.I.M., has been appointed head of the bureau and E. E. White, F.R.I.C., secretary. W. H. J. Vernon, O.B.E., D.Sc., Ph.D., D.I.C., F.R.I.C., F.I.M., has been engaged as consultant.

The services of the bureau will normally be free to members of the Association, and available to others on a fee paying basis.

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UNITED KINGDOM PRODUCTION OF PIG IRON AND STEEL

The production of steel ingots and castings in the United Kingdom in July averaged 263,100 tons a week, representing an annual rate of 13,682,000 tons. According to statistics issued by the Iron and Steel Board, Norfolk House, St. James's-square, London, S.W.1, the fall in output as compared with the previous month, when the weekly average was 371,700 tons and the annual rate 19,328,000 tons, was due to holidays and to temporary interruptions of production at plants of the Steel Company of Wales, and also, owing to mechanical difficulties, at one of the North-East Coast works.

The output of pig iron during July averaged 211,200 tons a week. The weekly average production in July last year totalled 202,400 tons.

LIGHTWEIGHT FIGHTER
New British Aircraft

Last week the Folland Midge, fore-runner of a new British lightweight fighter aeroplane, the Gnat, was transported, complete with wings and tail surfaces erected, by a road vehicle from its manufacturers' works at Hamble, Hampshire, to the Aircraft and Armament Experimental Establishment at Boscombe Down airfield. There, it successfully completed a series of four flights, after which it was flown off to Chilbolton airfield near Winchester, for further trials.

Some three years ago, Mr. W. E. W. Petter, C.B.E., chief designer of Folland Aircraft, Limited, realised that modern military aircraft were becoming so complex that, in the event of another "total war," it might well become impractical to construct them in the quantities required and to operate them from advanced bases. Thus was the private-venture Gnat lightweight fighter conceived. Pending the availability of the Bristol Orpheus jet engine for which the Gnat is designed, and which is still under development, the company have built the Midge aircraft, which is very similar in construction to the Gnat, but driven by a less powerful engine, the Armstrong-Siddeley Viper.

In addition to the advantages of rapid and economical construction, the easy transportability of the aircraft could be a great asset in time of war. Two such aircraft, with wings only removed, can be transported in a Blackburn Beverley air freighter, together with their pilots and ground crews.

* * *

VISCOUNT AIR-LINER
American Orders

On June 3, the sale of three Viscount air-liners to an American domestic air line, Capital Airlines, made history. Never before had a United States domestic carrier purchased British aircraft. At the time, the Capital company also took an option on 37 more Viscounts. This order has now been confirmed, it was announced by Vickers-Armstrongs Limited on Wednesday, August 11 and, in addition, Capital Airlines has taken an option on a further 20 Viscounts.

The sale of 40 Viscount air-liners, with spares, is the biggest sale ever made of a British air-liner and, it is believed, is the largest single commercial dollar export (45 million dols.) placed with any British industry for completely British equipment since the end of the second World War. The total value of firm orders for Viscounts (143 machines) amounts to £41 millions, including £11 millions in home orders.

It is expected that deliveries of the 40 aircraft will commence in March, 1955, and will be completed in August, 1956. If the further 20 Viscounts are ordered, their delivery will be completed by February, 1957.

* * *

THERMIONIC VALVES
Jubilee Celebrations

The Council of the Institution of Electrical Engineers have arranged for the Jubilee of the Thermionic Valve to be celebrated by the Institution on November 16, 1954, fifty years exactly from the date of the application by Sir Ambrose Fleming for a British patent.

The proceedings will be opened by the Lord President of the Council, the Marquess of Salisbury, and lectures will be delivered by Sir Edward Appleton, Professor G. W. O. Howe and Dr. J. Thomson, dealing with valves from the earliest developments to the present day.

An exhibition of historical apparatus will be held at the Institution.

Book Reviews

At Work for Europe. An account of the activities of the Organisation for European Economic Co-operation. *Organisation for European Economic Co-operation, Information Division, 2 Rue André-Pascal, Paris* (16e). (Free on application.)

Although most people are probably aware of the existence of the Organisation for European Economic Co-operation, few have clear ideas about its constitution and what it does. This pamphlet, which gives an account of its activities over the last six years, should therefore prove of interest. When the Organisation was set up in 1948, most Western European countries had to some extent recovered from the economic setback caused by the war, and productivity in the 18 countries belonging to the Organisation had reached 93 per cent. of the pre-war level in agriculture and 98 per cent. in industrial output. In 1953, the corresponding percentages were 120 and 141. Credit for the attainment of these satisfactory figures must be attributed largely to the generosity of the American people, but the efforts of the individual countries and the activities of O.E.E.C. have both been important influences.

The countries forming the Organisation agreed in general terms that they would each make the best use of their natural resources, modernise agricultural and industrial equipment, strive for full employment and reduce trade obstacles. Although the Organisation provides opportunities for mutual discussion and possible agreement, it is clear that the attainment of most of these objects depends on the activities of each individual country. In the matter of the reduction of trade obstacles, however, O.E.E.C. can take, and has taken, direct action and it is due to its efforts that quantitative import restrictions hampering intra-European trade have been modified. The European Payments Union, formed within the framework of O.E.E.C., has been equally effective in facilitating trade development. Briefly, it finances credits between member countries and makes bilateral balances unnecessary. An individual country in debt to another is relieved from embarrassment as its financial position is related to its net monthly balance of all the other member countries taken together. Details of the operations of the Union and its relation with the Bank for International Settlements must be sought in the pamphlet.

O.E.E.C. has set up various technical committees each concerned with some branch of industry; examples are electricity, iron and steel, machinery, and non-ferrous metals. The purpose of these committees is to study the problems confronting the particular industry with which each is concerned and to act as information centres. Technical missions to America have been organised and reports dealing with organisational and production methods have been published. An example was furnished by the report on the gasification of low-grade fuels, reviewed on page 9, *ante*.

A Concise History of Mathematics. By DIRK J. STRUIK. *G. Bell and Sons, Limited, York House, Portugal-street, London, W.C.*2. (14*s.*)

A valuable feature of this book is the bibliographies at the end of each chapter as these will enable the reader, who desires to do so, to study in more detail what has been written on this branch of science. The references are mainly modern and the number of them indicates the attention that has been given to the subject of mathematics.

As regards contents, some 250 pages in all are devoted to the Babylonian, Greek, Newtonian and modern ages of mathematics. The work of Euclid, Archimedes, Diophantos, Hammurabi, Bernoulli, Fermat, Euler, Newton, Leibnitz, Laplace, Lagrange, Gauss, Jacobi, Riemann, Cremona and Betti is analysed in detail, but it is a pity that the treatment has not been carried beyond the end of the Nineteenth Century. In dealing with his subject the author stresses the continuity and affinity of the oriental civilisations and skilfully distinguishes between fact, hypothesis and tradition, especially in describing work carried out by the Greeks. Coming to the Renaissance he relates the arithmetical-algebraic and the fluctional trends of that period to the commercial and engineering interests, the point being well made. In analysing Nineteenth Century mathematics he bases his exposition on persons and schools rather than upon subjects. Interest is added to the treatment by biographical details, although these are not unduly intruded.

The book may be recommended to the general reader, and an excellent index will facilitate its use as a work of reference. It may be added that the author is professor of mathematics at the Massachusetts Institute of Technology.

Fire and the Atomic Bomb. By D. I. LAWSON. Fire Research Bulletin No. 1. *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.* 6*d.*)

The explosion of an atomic bomb will cause total destruction within a central area, physiological injury to individuals situated in the neighbourhood of that area, and will start fires at distances which will depend on the atmospheric conditions ruling at the time. This informative bulletin is concerned only with the latter effect. The estimates presented concern what is referred to as a "normal atomic bomb" of the type dropped at Nagasaki, which releases energy amounting to 2×10^{13} calories, equivalent to 20,000 tons of T.N.T. The central area of total destruction is considered likely to extend to a radius of $\frac{1}{2}$ to $\frac{3}{4}$ of a mile from the explosion. The area over which fires may be caused by radiation will extend to a radius of about 2 miles.

It has been calculated that the temperature of the fire-ball of an atomic bomb is about 7,000 deg. C. during the period when most of the heat is being given out. Of the energy released, 56 per cent. would appear as heat radiation, 31 per cent. as light radiation, and 13 per cent. as ultra-violet radiation. The explosion produces a blue-white flash which lasts for only about a hundredth of a second so that the ensuing radiation does not last long enough to ignite materials on which it falls. The blue-white flash is followed by a second flash lasting about 3 seconds, during which heat equivalent to 7×10^{12} calories is given off. This is the period during which fires are started in the outer area.

It is not thought that serious fires will be started in the central area. The destruction would be so complete that incipient fires would be damped out by rubble. Flammable materials may, however, be ignited in the outer area extending over a radius of about two miles from the explosion. The actual distance will depend to a considerable extent on the state of the atmosphere. The greatest danger would be when visibility was greatest and particularly on summer afternoons and evenings when the humidity of inflammable materials would be low. It is not thought that doors and window frames would cause continuing fires, although they might inflame momentarily. Danger would lie in heat rays passing through windows and open doors and igniting papers, textiles, and upholstery. Dark materials are more dangerous than light ones. A number of cases were observed in Japan in which dark patterns on dresses were charred leaving the white parts intact.

As the heat radiations travel in straight lines, the lower parts of buildings in a town would be to some extent protected. In exposed rooms, combustible matter should be removed from the danger zone near windows; cotton materials could be made safer by treatment with a borax-boric acid solution. Some protection may be afforded by whitewashing windows or by fixing an incombustible board across the window space. This might be carried away by the blast, but not until after it had done useful work in intercepting heat rays. These measures would partially, or wholly, exclude light and a board set at an angle of about 45 deg. outside the window is suggested as an alternative.

TRADE PUBLICATIONS

Controls for Small Generating Sets. Various control units designed for operating small generating sets are described in a leaflet issued by Londex, Ltd., Anerley Works, Anerley-road, London, S.E.20.

Aluminium Roof and Wall Cladding. We have received from S. W. Ronald and Co. (London), Ltd., Bank Chambers, 329 High Holborn, London, W.C.1, an illustrated pamphlet giving particulars of Fural roofing and wall cladding. Fural is an alloy of aluminium and manganese rolled into strips of 22 s.w.g. and formed in a press into special corrugations which engage with a castellated fixing strip. The cladding is unrolled in horizontal bands across the roof, each band overlapping the one below it by 3 in. and offering a weather face 2 ft. deep between horizontal joints. The castellated fixing strips, fixed horizontally at 2-ft. intervals, form continuous horizontal members.

Refractories. The Morgan Crucible Co., Ltd. (Refractories Group), Neston, Wirral, Cheshire, have issued leaflets describing three of their furnace bricks: M.R.I, for temperatures up to 1,600 deg. C., with unusually good resistance to thermal and physical spalling; M.I.28, for temperatures up to 1,538 deg. C., weighing little more than a third of an ordinary refractory, and with a lower conductivity, so that furnaces built from M.I.28 heat up rapidly; and M.I.23 an economical brick for straightforward furnace insulation for temperatures up to 1,260 deg. C.

Calculating Machine. We have received from the Monroe Calculating Machine Co., Ltd., 10-11 Albemarle street, London, W.1, a leaflet describing their general purpose electrically-operated calculating machine which is capable of carrying out addition, multiplication, subtraction and division.

Stainless-Steel Centrifugal Pumps. The Howard Pneumatic Engineering Co., Ltd., Fort-road, Eastbourne, Sussex, have issued an illustrated leaflet briefly describing their range of stainless-steel centrifugal pumps for the food and chemical industries.

Chemical Plant. We have received from L. A. Mitchell, Ltd., 37 Peter-street, Manchester, two leaflets one of which illustrates examples of process plants they have supplied to the chemical industries; the other illustrating and describing mechanised conveyor-dryers.

Sectional Superheaters. A booklet, which explains simply the essentials of superheating theory and practice, has been published by Bolton's Superheater and Pipe Works, Ltd., Stockport. It also discusses the development of sectional superheaters and their application to all types of steam-raising plant. The booklet states that the age of cheap fuel has passed so that it is now necessary to extract more heat from the fuel available. This can be done with a superheater and how it is accomplished is explained in detail.

Large Steam Turbines. A handsomely illustrated booklet received from the Fraser and Chalmers Works of the General Electric Co. Ltd., Erith, is concerned with the design and construction of the large steam turbines which they manufacture. After dealing with the objectives, types and operating conditions of such plant, vibration and materials are discussed and the various constructional details are described. Information is also given regarding the governor gear and trip mechanism and the associated feed-heating plant. Finally, examples of plant which has been installed are illustrated by photographs and sectional drawings.

Diesel Engine Lubrication. The ninth booklet in the Vacuum Technical Series, published by the Vacuum Oil Company, Limited, Caxton House, London, S.W.1, has now been published. This edition is entitled "Diesel Engine Lubrication." Like the others in the series it is well illustrated by line drawings coloured to show the oil circuits. In all, 84 pages are devoted to explaining how Diesel engines of all types are lubricated, how they function, and the oils they use. Many manufacturers of Diesel engines and accessories assisted in the compilation of this useful booklet.

Rust and Shipping. Shipping stories from the Jenolite news, published by Jenolite, Ltd., 43 Piazza-chambers, London, W.C.2, have been reprinted with additional news features and technical notes in an attractive 16-page booklet. The articles are concerned with ships of all types that have been treated with company's rust removers and inhibitors.

BOOKS RECEIVED

Petroleum Microbiology. By ERNEST BEERSTECHER, JR. Published by Elsevier Publishing Company, Limited, and distributed by *Cleaver-Hume Press, Limited*, 31 *Wright's-lane, London*, W.1. (55*s.*)

Coal. Its Formation and Composition. By WILFRID FRANCIS. *Edward Arnold (Publishers), Limited*, 41 *Maddox-street, London, W.*1. (84*s.*)

Natural Airflow in Industrial Buildings. By E. FREIDIN. Research Bulletin No. 3. *Melbourne Technical College*, 124 *Latrobe-street, Melbourne, Australia*. (5*s.* plus postage).

Utilization of Saline Water. Reviews of Research. Issued by the Ministry of Education for UNESCO. *H.M. Stationery Office, Kingsway, London, W.C.*2. (10*s.* 6*d.*)

Report on the Derailment which occurred on February 3, 1954, at Watford, in the London Midland Region, British Railways. Ministry of Transport and Civil Aviation, Railway Accidents. *H.M. Stationery Office, Kingsway, London, W.C.*2. (4*s.* 6*d.*)

Bibliography of Books and Published Reports on Gas Turbines, Jet Propulsion, and Rocket Power Plants, January 1950 – December 1953. By ERNEST F. FIOCK and CARL HALPERN. Supplement to U.S. National Bureau of Standards Circular 509. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (50 cents.)

Automatic Digital Computation. Proceedings of a Symposium held at the National Physical Laboratory in March, 1953. *H.M. Stationery Office, Kingsway, London, W.C.*2. (21*s.*)

Standard X-ray Diffraction Powder Patterns. By HOWARD E. SWANSON, RUTH K. FUYAT and GEORGE M. UGRINIC. U.S. National Bureau of Standards Circular 539. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (45 cents.)

Radio. (vol. 2). By JOHN D. TUCKER and DONALD WILKINSON. *English Universities Press, Limited, St. Paul's House, Warwick-square, London, E.C.*4. (10*s.* 6*d.*)

Technical Reports of the British Electrical and Allied Industries Research Association:

H.V. D.C. Inverter Stations: Comparison of Cost of Supplying Reactive Volt-Amperes by Various Methods. By F. BUSEMANN. No. B/T118. (12*s.* 6*d.*)

Calculation of Transient Heating in the Dielectric of Single Core Cables. By H. GOLDENBERG. No. F/T179. (7*s.* 6*d.*)

Flameproof Electrical Apparatus: Flanged Joints One Half-Inch in Radial Breadth in Mixtures of Ethylene Oxide and Air. By T. J. A. BROWN and N. SIMPSON. No. G/T286. (6*s.*)

Present and Prospective Restriking Voltage Conditions on the British 132-kV and 275-kV Networks. By L. GOSLAND and J. S. VOSPER. No. G/T290. (10*s.* 6*d.*)

The Effects of Inclusions or Imperfections on Magnetization Processes in Silicon-Iron. By L. F. BATES and D. H. MARTIN. No. N/T66. (6*s.*)

The Operation of a Barn Hay Drying Installation. By P. FINN-KELCEY. No. W/T28. (15*s.*) *Offices of the Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.*

Sweden. Overseas Economic Survey. By W. G. R. HOWELL. *H.M. Stationery Office, Kingsway, London, W.C.*2. (6*s.* 6*d.*)

Practical Gear Design. By DARLE W. DUDLEY. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (7 *dols.*); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (50*s.*)

Introduction to Nuclear Engineering. By RICHARD STEPHENSON. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.*; and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (57*s.* 6*d.*)

Acoustics. By LEO L. BERANEK. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (9 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (64*s.*)

Balances, Weights and Precise Laboratory Weighing. National Physical Laboratory Notes on Applied Science No. 7. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.*)

The Coneygre Story. By W. K. V. GALE. *Coneygre Foundry, Limited, Tipton, Staffordshire.* (Free to approved applicants.)

THE ROYAL OBSERVATORY

TRANSFER OF INSTRUMENTS TO HERSTMONCEUX

The transfer to a distant new site of so complex an organisation as a national observatory, where precision and continuity of operation are first essentials, is a task of such magnitude as to justify all the comment it has received in the recently issued annual report of the Astronomer Royal, covering the period of 12 months ended April 30, 1954. Substantial progress in the removal from Greenwich to Herstmonceux has been achieved during the year under review. The pavilion for the Cooke Reversible Transit Circle has needed a little modification to the gear for operating the roof shutters, but has now been erected around the massive pier carrying the base casting of the instrument and collimators, which were already in position and adjusted for azimuth and level. Erection of the telescope itself is now nearing completion, but the cameras for photographic recording are still undergoing tests to determine exposure times. A printing micrometer which can be adapted for automatic recording of observations has been lent to the Observatory by Imperial College, while a photographic chronograph to eliminate the laborious work of reading tapes is in course of design. This last ancillary apparatus will embody a graduated and numbered disc rotating on the seconds spindle of a 1,000-c/s sidereal phonic motor. The disc will be photographed by a flash whenever the micrometer contact closes, thereby permitting the sidereal time of each contact to be read directly off the photographs.

Observations with the Airy Transit Circle, which remains at Greenwich after being in almost uninterrupted use for 103 years, were terminated at the end of March and meridian observations are temporarily in abeyance until the Cooke Transit can be brought into use at Herstmonceux. One of the last investigations made with the Airy instrument was a set of observations of double transits of azimuth stars, with concurrent measures of the azimuth of a survey beacon mounted on the old meridian mark obelisk at Chingford, eleven miles north of Greenwich. The measured azimuth of the mark, in conjunction with a triangulation survey from Greenwich to Herstmonceux, and a determination of the deflection of the vertical at the two stations from gravity anomalies, will lead to values of the astronomical latitude and longitude of the new site of the Cooke Transit Circle, for comparison with values obtained by classical astronomical methods. Analysis of measurements made with the Airy Transit indicate that azimuth errors may range up to 3 seconds as a consequence of diurnal temperature variations.

As regards the other major telescopes in course of transfer to Herstmonceux, the foundations and pavilion for the Photographic Zenith Tube are under construction, while plans for the pavilion to house the Bamberg Small Transit are nearing completion. The pavilion that housed the Cooke Reversible Transit Circle at Greenwich is to be modified to house the Melbourne Reversible Transit, with its collimators, at Herstmonceux.

During the year under review extensive preparations were made in readiness for the solar eclipse of June 30, 1954. The Observatory sent three parties of observers to Sweden. One, whose main objective was to study the Einstein

effect – the curvature of light rays and space due to the mass of the sun – took to Sydkoster a Field Equatorial converted for use in latitude 59 deg. The instrument was modified to permit rapid changing of 15-in. photographic plates covering 3½ deg. of field, and was strengthened, fitted with a rotary exposing shutter and sheltered from wind to prevent vibration during photography. The two other parties, equipped with ciné cameras, were positioned respectively just outside, and near the central line of, the zone of totality. It will no doubt be some considerable time before the results obtained are analysed, since no progress has yet been possible in the reduction of the films obtained at the eclipse of February 25, 1952.

The improved conditions for solar observation at Herstmonceux, as contrasted with those at Greenwich, are indicated by the fact that well-defined photographs of the sun were obtained on 302 days during the year. The sun is now nearing the minimum of the sunspot cycle. No sun spots were recorded on 190 days, January, 1954, being a completely spotless month. Only two spots, respectively, on August 17, 1953, and March 17, 1954, attained maximum areas equal to 500 millionths of the sun's hemisphere, while the mean daily sunspot number for the whole year was no more than 10, as compared with 27 for the preceding 12 months. The impending sunspot minimum is further indicated by the fact that only four solar flares, all of minor importance, were observed. The year was, nevertheless, noteworthy for active radiation of solar particles, the chief feature being a 27-day sequence of geomagnetic disturbance, extending for up to a week during each solar rotation from May to November, 1953.

The broad outline of the design for the mounting of the new 98-in. telescope for the Isaac Newton Observatory has now been decided, while details of the optical design and spectrograph requirements have been further considered. The mounting is to be of the offset fork type, having its polar axis in the form of an inverted and truncated cone. A design has been prepared for a model mechanism, which is to be made by the Engineering Laboratory at Cambridge University, to test Mr. B. N. Wallis's proposed method of artificially stiffening the telescope structure. The figuring of the 98-in. diameter glass mirror dish has reach a stage at which further refinement must be based on the results of optical tests. Preliminary observations with the disc vertical have shown that the present figure is reasonably satisfactory, despite some trouble from flexure of the disc near its supports and from stratification of air in the testing tunnel. Further tests are to be made, in the absence of earthborne mechanical vibration, with the disc horizontal, supported by air cushions so as to be free from strain.

OBSERVATIONS OF TIME

The Observatory time service is derived from basic observations upon stars, by means of transit instruments, which are subdivided by the vibrations of quartz oscillator clocks. For the first two months of the year under review Transit B was adopted as the standard Greenwich instrument, but was then replaced by another transit and withdrawn for inspection, having been in continuous operation for six and a half years. It was found that slight wear had occurred at those parts of the pivot which are in contact with the supporting Ys and the pads of the hanging level. However, the departure from circularity nowhere exceeded 1 micron and has no significant effect on the determined time. The pivots have now been chromium plated and the instrument is being reconditioned in the Observatory workshop at Greenwich. The determinations of time have been corrected for the effects of the earth's polar motion, which are based on current observations of latitude communicated regularly by the United States Naval Observatory. After this correction they have been compared with several selected quartz clocks and analysed to reveal the apparent annual fluctuation in the rotation of the earth. The result has been to show that the present value of that fluctuation is in close agreement with previous values observed for the past two or three years.

The practical time service is based on quartz resonator clocks employing silk-supported ring crystals, together with an experimental clock employing a GT-cut plate crystal which has been included because of its excellent performance. During the summer of 1953 the time determinations indicated an increasing systematic departure of the standard clocks from the performance predicted for them from observations during the previous year. Since intercomparisons among the clocks concerned gave no reason to suspect that the clocks had suffered any change, the divergence has been attributed to a change in the rate of rotation of the earth. At first this appeared to be a simple increase of speed, corresponding to a decrease of 1·3 milliseconds in the length of the day occurring in March, 1953. The magnitude and form of the change cannot be more precisely evaluated because of the considerable scatter in the time determinations, combined with uncertainty about the rate of frequency drift of some of the clocks. Subsequent evidence seems to suggest that the change may have occurred as early as December, 1952, and was more complex than a simple decrease in the length of the day.

The accuracy of the time service is enhanced by co-ordination of performance data relative to other quartz oscillator clocks which are maintained at the National Physical Laboratory; by the research establishments of H.M. Post Office at Dollis Hill and Banbury; by the B.B.C. receiving station at Tatsfield; and by the research division of Marconi's Wireless Telegraph Company. Experimental work to improve the clocks and the techniques of astronomical observation is also being pursued by the Observatory. It includes the perfecting of a photoelectric method of automatically recording star transits, that should be completely free from any personal error on the part of a human observer. The tentative system now under development has been successfully used on a number of occasions for recording transits and promises to form the basis of a practicable instrument. For intercomparisons among the clocks a high-precision frequency comparator is in course of development. The first experimental model exhibited accuracies of a few parts in 10^{10} and an improvement on this high degree of precision is expected from a new model now being constructed. The international time signals, the six-pip signals, and the hourly time signals used by the Post Office for the control of " TIM " – the telephone speaking clock – are controlled by phonic motor transmitters synchronised with the Observatory's quartz clocks at Abinger, in Surrey. At Greenwich, the Time Ball has been dropped regularly except on three days, one in January and two in March this year, when the wind force was too strong.

It is appropriate here to mention a most interesting and unusual " Astronomical Clock " which is to be the central feature of a Memorial, at York, to the air personnel from Northern Commands who lost their lives in the War. The exterior of the clock is being designed by Professor A. E. Richardson, R.A.; the mechanism by the Astronomer Royal's chief assistant, Dr. R. d'E. Atkinson. The principal mechanical element of the clock will be a planisphere rotating behind a fixed horizon once in a sidereal day, and carrying a " Sun " which will advance along a circular " Ecliptic " at the proper rate to take account of the equation of time. As the south pole, not the north pole, has been projected to the centre of rotation, the horizon is convex instead of concave. It is sensibly circular, so that the impression conveyed to an observer will correspond as far as possible to that of an airman immediately above the city of York. The " Sun " will rise and set every day at the correct times and azimuths for York, and will also reach all other " azimuths " and " altitudes" at the correct times, full automatic account being taken of leap years, of precession, and of the equation of time. There will, in addition, be a circumpolar dial and various smaller subsidiary dials, but no representation of the moon and planets since in their case comparable accuracy cannot practicably be attained. The construction of the clock is being undertaken in the Royal Observatory workshop on a voluntary overtime basis.

GEOPHYSICAL OBSERVATIONS

In the course of his Report the Astronomer Royal mentions that the year 1957-58 is to be observed as an International Geophysical Year, during which special observations of longitude, latitude and seasonal variations in the earth's rate of rotation and polar movements are to be included among geophysical investigations at many observatories throughout the world. He urges the importance of Herstmonceux being tied into the network of observing stations during that year. The transfer from Abinger to Herstmonceux of quartz clocks, control panels and other equipment of the Observatory Time Department will necessarily be a lengthy operation. Moreover the quartz oscillators will need some months to settle down to steady performance after being moved. It is therefore of great moment that the new building to house the Time Department at Herstmonceux should be completed before the end of 1956.

The Magnetic Observatory is having to be removed from Abinger, where observations are disturbed by the local electrified railway lines, to a site near Hartland in Devonshire. After the necessary buildings have been erected on the new site, an overlap of observations there and at Abinger, extending over at least a year, will be essential. It is desirable that this period of overlap should include the International Geophysical Year, so that the magnetic data for that year may include results from two observatories in the south of England as well as from two northerly stations, at Eskdalemuir and Lerwick respectively. The Astronomer Royal therefore urges that buildings on the Hartland site should be sufficiently advanced for magnetic observations to begin there not later than the middle of the year 1957.

Meantime, at Abinger, regular observations of declination, horizontal intensity and vertical intensity have been made throughout the year. The mean annual values of the magnetic elements for the past four years, with estimated values for 1954, are tabulated below:—

Year	Declination (West)		Horizontal Intensity	Vertical Intensity	Inclination	
	deg.	min.			deg.	min.
1950	9	19·7	0·18628	0·43288	66	43·0
1951	9	12·2	0·18648	0·43305	66	42·1
1952	9	4·7	0·18671	0·43316	66	40·9
1953	8	57·5	0·18697	0·43321	66	39·3
1954	8	50·0	0·18725	0·43331	66	37·7

The values of all the elements display quite regular trends, and call for no comment beyond, perhaps, a remark on the high degree of precision with which the measurements can be made. This depends not only on the fine quality of the apparatus employed, but also on the meticulous care with which it is used and maintained, exemplified by the fact that the potentiometers used with the coil instruments for the measurement of horizontal and vertical magnetic intensities are checked at the National Physical Laboratory once every year. At longer intervals the dimensions of certain of the coil instruments are remeasured at the N.P.L. to ascertain whether any secular changes are taking place. In one such check, on the Schuster-Smith coil, measurements last April disclosed no significant dimensional changes since the previous check in November, 1931.

One other function of the Observatory, which may be mentioned in conclusion, is the regular observation of meteorological phenomena. Consequent on the termination of the meteorological service at Greenwich, full-scale observations were started at Herstmonceux on November 1 last, readings being made at two specified hours

every day and, additionally, at an intermediate hour on working days, on recording instruments. Before the Observatory's standard barometer was brought into use at Herstmonceux it was empirically checked at the National Physical Laboratory and found to have suffered no significant change in performance since its previous calibrations in 1866 and 1877. On the other hand, a recording barometer, transferred from Greenwich to one of the cellars in Herstmonceux Castle, at first showed some instability in the deduced values of the recorded base line. The trouble was traced to defective centring of the float within the glass tube, but has now been corrected. The other meteorological instruments in regular use include a Dines pressure-tube anemograph, a Negretti and Zambra dry and wet-bulb thermograph, two 5-in. rain gauges and a Meteorological Office pattern recording rain gauge, a solar-radiation thermometer, two grass-temperature minimum thermometers, a deep-sunk thermometer, and all the other usual meteorological thermometers mounted in a standard double Stevenson screen.

For the 12 months covered by the report, bright sunshine was recorded at Herstmonceux for 1,826·8 hours, representing 0·408 of the total possible duration. On the whole it was a year of rather dull, relatively cold, weather. Throughout the last six months, ended April 30, 1954, the air temperature never reached 60 deg. F., and on 28 days air temperatures below freezing point were recorded, the mean air temperature for the half-year being 42·9 deg. F. For the same period the total rainfall amounted to only 10·79 in., most of April being exceptionally dry following a spell of 18 rainless days from November 26 to December 13. The mean velocity of wind was 7·4 knots, the maximum gust of 57 knots (66 m.p.h.) being measured on January 15, 1954.

ELECTROLYTIC DERUSTING

PRINCIPLES AND APPLICATIONS OF THE PROCESS

By L. Kenworthy, M.SC., A.R.C.S., F.R.I.C., F.I.M., *and T. F. East*

The removal of rust from ferrous materials, either as a preliminary to paint application or in order to achieve mechanical efficiency, is a problem which needs no emphasis to the engineer. The necessity for carrying it out, however, and the man-power which it entails, make it imperative that the methods used should be as efficient and economical as possible. With these objects in view, attention has been given in recent years to the development of the electrolytic method of cleaning, which appears capable in many instances of superseding the traditional mechanical, chemical or thermal methods of derusting, and of being employed where these methods are inapplicable.

The electrolytic cleaning process consists simply of making the article to be cleaned the cathode of an electrolytic cell and passing a current until the rust has been removed. The possibilities of applying this principle to ships' cleaning problems were demonstrated in the late war for cleaning the cargo tanks of tankers. In particular, it was shown that the cheapest and most accessible electrolyte available to marine engineers, namely the sea, could be successfully used for certain applications.

Since 1946 the Admiralty have been investigating the principles and applications of the process to naval service. As a result, electrolytic cleaning has now become a normal routine for certain components and the success achieved is leading to its extended application. The articles which have been treated include the ballast tanks of submarines, bathrooms, turbines, superheater headers, small internal-combustion engines, cooking utensils, decks, mine shells, chain cable and shackles. The process has also been developed for the cleaning and, incidentally, the disassembly, of smaller corroded components and mechanisms.

OUTLINE OF THE PROCESS

Before describing the detailed application of the process, a number of general considerations will be discussed. Briefly, the process consists of passing a direct electric current at low voltage (up to 12 volts), and of as high an amperage as can conveniently be obtained, through an electrolyte, the article to be cleaned being made the cathode and either a steel tank or an array of iron or steel plates, or bars, the anode; alternatively, an inert anode of carbon may be used.

The electrolytes that are being used by the Admiralty are mainly sea water or caustic-soda solution, although others have been used for special purposes. Whatever the electrolyte, this undergoes decomposition by the current, hydrogen gas being generated at the cathode. The hydrogen so produced has a reducing, scouring and lifting effect on the rust, as the action takes place at the interface of the rust film and the parent metal.

Additionally, if the electrolyte contains certain salts such as chlorides, sulphates, nitrates, fluorides, phosphates, or cyanides which are decomposed by electrolysis, ions are released at the anode that are capable of dissolving metals or metallic oxides; consequently by reversal of the current for carefully controlled periods, the cleaning action can be intensified when necessary. It is, of course, undesirable for these salts to be present in too high a concentration when current reversal is employed, as there will be a degree of attack on the article commensurate with the activity and quantity of the ions released during electrolysis. For this reason current reversal is generally to be avoided when using sea water because of its high chloride content.

The main advantages of the electrolytic process over other methods of derusting are:—(*a*) Cleaning is achieved without any attack of the metal surface (provided no current reversal is practised), which is, in fact, cathodically protected during the process; the method is therefore eminently suitable for machinery components the dimensional tolerances of which are important. (*b*) The process is particularly effective in loosening assemblies which cannot otherwise be taken apart because of adherent rust or scale. (*c*) There is no dust or noise associated with the process and no distortion or bruising of the article being cleaned. (*d*) It is economical in man-power and material and no skilled attention is required.

The principal limitation of the method is that it will not remove mill-scale since this is a good conductor of electricity and because it is so non-porous and tightly adherent that the electrolyte cannot penetrate. The process is also not particularly effective for cleaning cast iron. Moreover, certain precautions must be observed when dealing with composite assemblies involving non-ferrous metal parts. Thus, if aluminium fittings are present, the article must not be derusted in caustic-soda solution or the fittings will be dissolved; even if sea water is used as the electrolyte there may be some pitting of the aluminium by the caustic soda generated by the electrolysis. Zinc, lead, tin and solder tend to dissolve into a caustic-soda electrolyte and later may be deposited on the iron being derusted. This drawback can be overcome, however, by reversing the current for a few minutes, thus making the component the anode, whereby any deposit of these metals is dissolved.

The *modus operandi* of the process is governed by the type of article to be cleaned, three major variants being necessary to deal respectively with the following three classes of article: (*a*) small components which can be immersed in a tank; (*b*) larger articles which cannot be immersed in a tank of convenient size, but can be suspended in the sea; (*c*) components which must be dealt with *in situ*.

The low-voltage high direct-current supply required may be obtained from alternating-current mains by an appropriate assembly of transformers and electroplating rectifiers and such an arrangement, having no moving parts, may be employed continuously without skilled attention. Alternatively, electroplating generators or direct-current welding sets could be utilised for occasional work.

The relationship between current density and the time required for cleaning is such that at low currents of 0·5 ampere per square foot and below, the time increases rapidly with decreasing current density, but, at higher voltages at 3 amperes per square foot and upwards, the decrease in time is small compared with the increase in current. In general, it has been found that the most suitable current density is between 1 and 2 amperes per square foot of cathode area when using sea water, although somewhat higher values may be advantageous with caustic-soda solution. Within this range, the time required to clean may vary between 6 and 48 hours or more, depending upon the state of the surface.

In some instances it may happen that patches of very recalcitrant rust need an undue time to effect their removal electrolytically. In such cases, it would clearly be uneconomical to continue the process for, say, 30 hours when all but these patches had been cleaned in 10 hours. For practical purposes, therefore, the time for cleaning should be regarded as that required to reach a stage when at least 90 per cent. of the rust has either become detached or loosened to such an extent that it can be readily removed by hosing down or by light brushing; relatively little mechanical effort should then suffice to remove the remainder.

If paint is present which is tightly adherent the normal period of cleaning will probably not remove it and ordinarily it is desirable to allow it to remain if the adhesion is good at the conclusion of the electrolytic process. If, for any reason, it is necessary to remove tightly adherent paint, this can be achieved electrolytically, but the process may take an excessive time, depending on the thickness, nature and conditions of the paint.

In view of the low resistance of the electrolyte and the small potential difference between the electrodes, a reasonable latitude should be allowed for positioning the source of current, but it should not be too far away. Another advantage gained by these conditions is that a wide range of material can be used for insulating the anode system from the cathode. Thus, even wet rope or wooden battens offer sufficient resistance to prevent any "shorting" of the circuit.

During the process, hydrogen is given off at the approximate rate of 1 cub. ft. per 70 ampere hours and since this introduces the risk of explosion, it is necessary to ensure adequate ventilation. To give a reasonable margin below the safety limit of air-hydrogen mixtures it has been determined that the hydrogen in the mixture should not exceed 1 per cent.

SMALLER COMPONENTS FOR TANK IMMERSION

For small components capable of tank immersion, 4 per cent. caustic-soda solution is generally used as the electrolyte by the Admiralty. This has a number of advantages over sea water where only a limited volume of electrolyte is required. Thus, in the first place, it does not introduce chlorides, which are undesirable when dealing with machinery components. Secondly, when caustic soda is electrolysed, only oxygen is liberated at the anode; consequently a steel anode is not attacked and the electrolyte may therefore be contained in a mild-steel tank, the latter itself being used as the anode. Thirdly,

there is no deposition of salts on the article being cleaned as occurs when using sea water. With the latter electrolyte, a film consisting of the oxychlorides of calcium and magnesium is deposited and while this may be unobjectionable in dealing with large structural items, it would be undesirable on machinery components.

The size of the tank is not important, but 5 ft. by 5 ft. by 4 ft. 6 in. made of ¼-in. mild-steel sheet and holding 500-600 gallons of electrolyte is appropriate for most purposes. The top of the tank should preferably be flanged over for about 2 in.; this gives added rigidity and provides a seating for the insulators to which are secured the copper bus-bars connected to the cathode leads. The anode lead is, of course, attached directly to the tank. It is desirable to have a spare tank adjacent to the derusting tank to receive the caustic-soda solution when the removal of sludge becomes necessary.

For derusting a number of small objects which are not in good electrical contact, such as shackles, grips, bolts or the links of chain cable, it is particularly important that sea water should not be used as the electrolyte because the imperfect contact will result in some parts of the components becoming anodic with consequent pitting and wastage; this does not occur with caustic soda. The most satisfactory way of dealing with such articles, other than chain cable, is to place them in a large-mesh iron wire basket which can be shaken occasionally as derusting proceeds, thereby ensuring that adequate electrical contact is obtained. Chain cable should be bundled with binding wire, which must be of iron, as copper rubbed off from copper or brass wire would be a site of subsequent corrosion.

When operating the electrolytic process in this way, consideration should be given to installing, in addition, tanks for preliminary and subsidiary treatment of the articles. Thus it is of great assistance to submit the articles to be cleaned to a preliminary degreasing operation, since surfaces contaminated with oil and grease, being poor conductors of electricity may otherwise require prolonged treatment in the electrolytic cleaning tank.

After derusting, it is advisable to remove traces of caustic soda retained on the surface of the articles. This can be accomplished by a dip in fresh water. In addition, to complete the neutralisation of the caustic soda, and also to provide some slight temporary anti-corrosive treatment prior to returning the articles to service or to giving them a more permanent treatment in store, a final dip in a dilute (2 per cent.) phosphoric acid solution is an advantage. A mild-steel tank provided with a lead lining should be used for holding the phosphoric acid solution. A further tank containing de-watering oil should be provided for a fitting-shop plant to receive small components awaiting reassembly after derusting.

For certain applications, it may be found that cathodic treatment alone in caustic-soda solution will not give the desired degree of cleaning and brightness of finish. This may be remedied as previously stated, by the addition of various salts to the solution (typical compositions are given in British Standard Packaging Code B.S. 1133/1943) and reversing the current for a short period to make the article being cleaned, the anode. In doing this, care must be exercised however, or severe attack of the article may occur. Moreover, it should be noted that with these additions to the bath, the tank itself, which is acting as anode for most of the time, will be attacked and will therefore not have the same length of life as when plain caustic soda is used.

LARGER ARTICLES TO BE SUSPENDED IN THE SEA

For larger articles treated by suspension in the sea, either iron or carbon may be used as the anode. Carbon electrodes have the advantage that they are not attacked by the chlorine generated by electrolysis but, on the other hand, they are fragile and initially expensive, whereas any scrap material of suitable dimensions can be used for metal anodes. Generally speaking, therefore, iron anodes are to be preferred, and carbon anodes should only be used when cleaning a large number of similar objects such as buoys or mines; for this purpose, an array of carbon electrodes could be set up which would prove economical in operation.

The articles which have so far been dealt with in Admiralty service by suspension in the sea include cylindrical buoys and mine casings, although the latter are small enough to be a practicable proposition for tank processing with caustic soda. The anode array for the cleaning of a large buoy, approximately 15 ft. by 8 ft. by 8 ft., consisted of two lengths of steel pipe 10 in. in diameter and 10 ft. long, slung in a rope saddle passed over the floating buoy so as to be 18 ft. below the surface of the water on each side of the buoy and 10 ft. apart. The buoy could thus be treated a segment at a time by rolling it over as required. Complete immersion enabling derusting to be carried out in one operation, would have been preferable but such a buoy could not be flooded, and other methods of sinking it would have presented difficulty.

As previously stated, during the process using sea water as the electrolyte, a cathodic film of insoluble calcium and magnesium salts is deposited on the surfaces being cleaned. This film possesses little protective value of its own although attempts have been made by silicate washes to improve its qualities in this respect. It has been stated that the film forms a good basis for paint, but the authors are of the opinion that there is a danger of alkali remaining adsorbed by the film even after hosing down with fresh water. Hence where it is necessary to apply a paint coating, only paints with non-saponifiable media, such as the bituminous type, should be used. It is advised, however, in order to eliminate restrictions of this nature that more positive steps are taken to remove all traces of alkali. The best way of doing this is to brush the surface after the completion of the electrolytic process to remove the attached, but loosely adherent, rust and scale; this should preferably be followed by hosing down with fresh water. After draining, a 2 per cent. solution of phosphoric acid should be hosed or sprayed on, to neutralise any residual alkali, and the paint subsequently applied when the surface is dry.

APPLICATION " IN SITU "

Large Tanks and Compartments.—In the case of large tanks or compartments of ships to be treated *in situ*, sea water is the most suitable electrolyte because of its ready availability and cheapness. For this purpose, steel and not carbon anodes must be used, since, with a carbon electrode, chlorine is freely evolved and this will constitute a health hazard in a confined space. In order to obtain effective cleaning, it is necessary to construct an " anode network " within the tank. The structural details will, of course, vary with the size and shape of the tank, but the main considerations to be taken into account are described below. If painting is necessary after cleaning, the procedure to be adopted should be similar to that described above.

The anode can be any length of steel (scrap if available), whether rod, tube or angle-bar, but it is not advisable to use a rod of less than 1 in. diameter, or equivalent sectional area, for structural reasons and from considerations of electrical conductivity. Few areas to be cleaned are so simple that there are no projecting parts, and this means that preferential wastage of the rod at points nearest the cathode will occur.

The next item to be considered is the anode network or disposition of the rods which will act as the equivalent to a large plate anode. It is advisable to place each rod at a distance of not more than approximately 3 ft. from the cathode and to consider its radius of action to be about 4½ ft. on each side of the nearest part of the cathode. One horizontal anode, therefore, will clean a tank which is 6 ft. broad and 9 ft. deep. The length is immaterial, since the rod is made to suit. In order to clean the ends of the tank, a plate about 1 sq. ft. in area is fixed to each end of the rod, which terminates about 3 ft. from the tank ends. In general, therefore, one rod with plate ends will clean an area of 108 + 24 L sq. ft. of tank surface (when L is the length of the tank in feet).

Approximately 1 lb. of iron is dissolved from an anode for every 435 ampere hours, so, to be on the safe side, the network should contain at least 1 lb. for every 100 ampere hours to prevent collapse. Joints in the network which are under water may be bolted together, but those in the bus-bars carrying the main electric supply should be welded. In general, the anode network may be fixed by ropes and wooden battens; if it approaches nearer than 6 in. to any projection on the tank, that area of anode should be shielded with rubber tubing. If a deep cavity has to be cleaned at the same time as the surfaces, an auxiliary anode rod can be suitably supported therein and connected to the main network.

The cables carrying the current should not be connected directly to the network. This will avoid the sea water becoming contaminated with copper which might deposit on the surface and subsequently set up extensive corrosion. It is necessary, therefore, to run an iron bus-bar from a suitable part of the network to some spot where there is no chance of its being wetted by the electrolyte. Normally, the allowable section of copper is 1 sq. in. per 1,000 amperes, and since iron has a specific resistance approximately ten times that of copper, the bus-bar should theoretically be of corresponding proportions. However, since the greater part of it is in water and as the heat generated is conducted away, this ratio can be smaller and three times the copper section has been found quite satisfactory. The bus-bar may therefore be an iron bar 3 in. by 1 in., the outer end of which is suitably drilled to take the bolts for clamping the cables. The other end is inside the tank and attached to the network.

Turbines.—The value of the electrolytic cleaning process is evident when turbines require cleaning, since the removal of corrosion products from the blades by mechanical means, and without damage, in the restricted spaces between blades and between rows is particularly difficult and time-consuming. An illustration of how the method is carried out can best be given by the following brief account of the cleaning of an high-pressure marine turbine.

The process was carried out in two stages. In the first stage, the top half of the casing was cleaned after raising it well above the bottom half; in the second stage the rotor and bottom half of the casing were cleaned together, the rotor resting in its bearings.

The plate which was fixed across the flange of the casing to contain the electrolyte was also used as the anode. This plate was of mild steel about ½ in. thick. It was insulated electrically from the case by the use of rubber sheet which extended inside for about 6 in. from the edge of the casing. The bolts, etc., holding the plate in position were insulated from both casing and anode plate. Power leads were taken from suitable connections on the anode plate and on the casing.

The anodes for treating the lower half of the casing and the rotor were semi-annular rings of mild steel about ⅛ in. thick, 2 in. wide and 3 ft. 6 in. in diameter. To avoid " shorting " on to the blading they were completely encased in a close fitting canvas cover and slipped between the expansions, as only here was there enough room to insert them. Six anodes were used and connected in parallel to the positive lead from the power supply. The negative lead was connected to the lower half of the casing and to the rotor, by means of a clamp on the impulse wheel. The rotor was cleaned in three runs, the shaft being rotated 120 deg. between each run.

In view of the fact that corrosion of stainless-iron marine-turbine blading is probably always due, in some measure, to salt-water contamination, it appeared to be preferable not to use sea water as the electrolyte. A 4 per cent. solution of caustic soda was therefore used, as the spaces

between rows and blades was sufficient to permit light brushing to remove particles of rust which had been loosened but not freed. In certain cases where there is very limited space, and it is desired to clean the blading completely without brushing, the use of one of the more complex electrolytes referred to earlier may, however, be necessary, with controlled current reversal.

The power was supplied from a generator in the ship which could supply enough current (300 amperes) up to a pressure of about 16 volts.

After electrolysing for about 48 hours at a current density of about 5 amperes per square foot, cleaning was complete. The electrolyte was removed, and the turbine was then hosed down with fresh water and kept wet until the removal of loosened rust was completed by light wire brushing. After a final hosing down, a 20 per cent. solution of sodium nitrite was sprayed on to the surfaces to act as a temporary inhibitor against further corrosion.

Outer Bottom Plating.—The application of the process for cleaning outer bottom plating has been studied only to a limited extent, the most ambitious trial being that carried out on a submarine while in dock. In this case the anode array consisted of an assembly of steel plates suspended around the hull on floating rafts. The current from four generators in parallel was led into the array at several points to equalise the current distribution. Employing a current density of 0·2 amperes per square foot, the operation was completed in about four days when patches of rust up to $\frac{1}{16}$ in. in thickness had flaked off and others were easily removable by light scraping. An important feature of the trial was the effective derusting which was achieved under the casings of the submarine, where access is difficult by other methods.

In certain ships of the Reserve Fleet, successful experiments have been carried out on the descaling of water-line areas of outer bottom plating. Various anodes were tried, such as lengths of expanded steel, steel rods, carbon rods secured by canvas backing and 3 in. steel-wire rope. The latter type of anode although extremely easy to fix was found to have a very limited life and, on the whole, an array of steel rods is probably the most serviceable.

Decks.—The process has been used experimentally for derusting the decks of ships in the Reserve Fleet. Initially the technique used was to cover a badly rusted portion of the deck with a paste of sea water and asbestos fibre approximately $\frac{1}{2}$ in. thick and 2 ft. by 2 ft. in area. An iron anode was then placed over the paste and a current of 100 amperes passed. The rust was removed in thick flakes after about half an hour, leaving a dull surface free from rust, which was very suitable for painting. Subsequently, an improved technique was adopted which consisted of iron-mesh electrodes contained in canvas bags filled with sea water.

CONCLUSIONS

The development of the electrolytic cleaning process for Admiralty purposes has aimed at cheapness and simplicity, bearing in mind the many *in situ* and large-scale applications. Sea water or caustic-soda solution are the electrolytes normally used and although it is recognised that more complex electrolytes have their special uses, for the vast majority of applications, as described in the present article, these have been avoided as being undesirable either for technical or economic reasons.

From the examples that have been given of the wide variety of articles which have been cleaned successfully by the electrolytic process, it will be clear that the method is capable of being applied to almost any rusted surface. The technical limitations of the process are few, whereas the numerous advantages which it possesses over other methods of cleaning would appear to make it an attractive proposition in the engineering and marine industries.

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CREEP AND FRACTURE OF METALS AT HIGH TEMPERATURES

SYMPOSIUM HELD AT THE NATIONAL PHYSICAL LABORATORY

By E. I. Brimelow, M.ENG., A.I.M., ASSOC.I.MECH.E.*

A symposium on the Creep and Fracture of Metals at High Temperatures, a subject of considerable practical importance and theoretical interest, was held at the National Physical Laboratory, Teddington, from May 31 to June 2, 1954. It was attended by eminent scientists, metallurgists and engineers from many countries, including Belgium, France, Germany, Holland, Italy, Japan, Norway, Sweden, Switzerland, the United States and the U.S.S.R. as well as from the Commonwealth countries and the United Kingdom. The visitors were welcomed by Sir Edward Bullard, the Director of the N.P.L., who took the Chair at the Opening Session.

The symposium provided an excellent opportunity for workers interested in fundamental problems concerning the strength of metals and alloys at high temperatures, to get together to discuss new ideas that had arisen concerning plastic deformation and fracture, since the last short conference on Creep in Metals arranged by the N.P.L. in 1946. The papers presented, and a record of the discussion, will later be published in extenso as "Proceedings" of the Symposium, by H.M. Stationery Office. In the interim, this synopsis is intended to outline some features that may be of immediate interest to those concerned with the application and development of high-temperature metals.

PRACTICAL IMPLICATIONS OF CREEP PHENOMENA

In his introductory paper[1] Dr. N. P. Allen Superintendent of the Metallurgy Division, referred to present-day problems in the development and use of creep-resisting alloys. In particular he stressed the need for more information on the creep behaviour, over very long periods, of special heat-resisting steels originally developed for use in aircraft gas turbines on the basis of a comparatively short life of 300 hours, or less. At present, he said, there was a considerable interest in power units having a much longer life, up to 100,000 hours for commercial aircraft, marine and land power units. Extensive series of creep tests made at the N.P.L. for periods of 10,000 hours or more had confirmed the sound practice of lowering the working temperature of a gas-turbine engine as the expected life was increased. On the other hand, if a high thermal efficiency were required some sacrifice of working life might be necessary. An example of the difficulties of predicting the behaviour of certain steels in service from the results of creep tests under very different conditions as regards duration and stress, was the cracking of 0·5 per cent. molybdenum-steel steam pipes occurring in a power station. These pipes failed in an unusually short time although the long-term creep test results at moderate stresses were satisfactory. It had been subsequently shown that the failures were due to high short-lived stresses set up at points of stress concentration by thermal stresses arising from irregular operations under war-time conditions. This example, Dr. Allen emphasised, showed the complexity of questions of fracture and the need for understanding the behaviour over a wide range of creep conditions.

A question of practical importance to the designer of large power units was the effect of size of component on creep properties, namely whether large components made in a particular steel could be expected to have creep properties at least equal to those shown by small test pieces. A few creep tests were therefore made at the N.P.L. on an austenitic-steel disc 18 in. in diameter by 4½ in. thick, and a ⅝-in. diameter bar of the same composition, also with steam pipes 13 in. in diameter by 2 in. thick and superheater tubes 1¾ in. in diameter by $\frac{1}{16}$ in. thick made in a ferritic 0·5 per cent. molybdenum steel, and a similar comparison was made between pipes and tubes in an austenitic steel. The results were reassuring in that although the shape of the creep curve was affected by different manufacturing processes associated with the size and form of the component, average creep rates taking into account directional effects in the large components, were not appreciably different.

The tendency to increase working temperatures in both steam and gas turbines had posed new problems. This trend to higher steam temperatures, in the case of steam turbines, from its former maximum of 550 deg. C. to 600 deg. C. and probably 650 deg. C., had raised economic problems as to the temperature at which a ferritic type steel such as the 0·5 per cent. molybdenum, 0·25 per cent. vanadium steel should be replaced by more costly austenitic-type steels such as 18 per cent. chromium, 12 per cent. nickel, 1 per cent. niobium steel, which were certainly superior above 650 deg. C. but offered no advantage at temperatures below 550 deg. C. Creep tests on the above ferritic steel at 626 deg. C. and on the austenitic steel at 635 deg. C. had shown the austenitic steel to be much superior in creep resistance at stresses of the magnitude of those met with in superheater devices and steam pipes. It was questions of this kind, Dr. Allen pointed out, that emphasised the importance of knowing the origin of the increase of creep rate that occurred in the third stage of creep.

FRACTURE UNDER COMPLEX CREEP CONDITIONS

Of considerable practical importance is the study of the fracture of metals under complex creep stress conditions. Most of the information available concerning the creep properties of metals and alloys is based on tests under simple tensile or compressive stresses, although it is well known that fractures in service have frequently occurred under more complex stress conditions. From this point of view the paper[2] by Dr. A. E. Johnson and Mr. N. E. Frost, of the Mechanical Engineering Research Laboratory, was a most useful contribution. This work showed that for a 0·5 per cent. molybdenum steel at 550 deg. C. the time of fracture and the nature of the fracture depended on the stress system. For example, under a simple tensile stress of 9 tons per square inch, intercrystalline fracture occurred after 684 hours, and under a pure torsion stress of 6·5 tons per square inch a transcrystalline fracture occurred after 1,403 hours. With a combined stress system of 9 tons per square inch tension and 5 tons per square inch torsion, fracture occurred after 234 hours and was partly intercrystalline and partly transcrystalline. The results so far obtained in this investigation of the effect of complex stress systems led to the tentative conclusion that the criterion of fracture may be the maximum principal (tensile) stress of the system imposed.

FORMATION OF INTERCRYSTALLINE CRACKS

The rapid development of fractures in such components as bolts and blade-root attachments, that is, those of a type embodying structural notches, even when made in heat-resisting steels, has led to investigations into the development of intercrystalline fractures in various steels under

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tri-axial stress condition, such as are set up when notched specimens are stressed. The results of creep tests on a wide range of metals under these conditions formed the subject of an interesting paper[3] by Dr. W. Siegfried (Sulzer Brothers, Limited, Switzerland). He found that there were three ways in which cracks may develop in cold-worked specimens, namely, (*a*) intercrystalline cracks running transverse to the direction of pull and beginning at some distance from the root of the notch, (*b*) partly crystalline and partly intercrystalline cracks at the root of the notch itself, not penetrating far into the interior, and (*c*) haphazardly distributed intercrystalline cracks in the interior of the specimen, produced by the opening of the grain boundaries. He further concluded that the stress action under these conditions was influenced by a large number of factors and explained the results by introducing two strength properties, namely, the resistance to deformation (transcrystalline flow) and the cohesive strength (resistance to intercrystalline cracking) of the material. These two strength properties, however, were not constant, but varied as a function of the test duration. Besides being dependent on time they were influenced by the precipitation processes which again depended on the creep process itself. Dr. Siegfried summarised the action of the various factors on the two strength properties, as established by his tests, in Table I, which is reproduced herewith.

NOTCH EFFECT

The effects of a " V " notch on the tensile-creep behaviour of a 0·5 per cent. molybdenum-0·2 per cent. vanadium steel within the temperature range 525 deg. C. to 650 deg. C. at stresses of 5 to 17 tons per square inch, were discussed in a paper[4] by Mr. R. W. Ridley and Mr. H. J. Tapsell, of the National Physical Laboratory. The form of notch used in these tests was 0·02 mm. deep with a root radius of 0·25 mm. and an angle of 45 deg.; it was machined circumferentially round the centre of the test piece and was considered to be reasonably representative of the sort of stress raiser that could occur in steam-power components due to service defects as, for example, in the form of rough machining marks or grooves in bars or pipes. A comparison of the creep curves for these notched and unnotched test pieces of steel, in the condition as air cooled after 15 minutes at 1,000 deg. C., suggested that if the permissible creep during service life was limited to 0·2 to 0·3 per cent. for temperatures of 600 deg. to 625 deg. C., the existence of small surface defects would not be expected to produce a decrease in service life for the specified creep. It should be noted, however, that these conclusions are based on tests under symmetrical stress conditions and do not necessarily apply for unsymmetrical stresses, as in bending.

FACTORS INVOLVED IN THE CREEP PROCESS

One of the greatest drawbacks to a clear understanding of the creep process has been the large number of variables involved. It is, therefore, not surprising that many of the creep data available have been obtained under widely differing test conditions, so that it has been difficult to determine how the various factors involved affect deformation. Papers reviewing available data and giving the results of programmes of creep tests on various metals, designed to determine the precise function of the various factors involved in the creep process, were a most useful contribution to the symposium.

It was recognised by several of the authors who made surveys of experimental results that points at which " breaks " in the log-log plots of stress versus rupture life occur are indicative of critical conditions where a new cause of instability becomes active. Some of the causes suggested were: grain growth or boundary migration, recrystallisation, intergranular micro cracks, oxidation (intergranular), spheroidisation or change in composition of segregated phases. These various causes and their influence on the mechanism leading to rupture were considered[5] by Dr. C. Crussard and Mr. J. Friedel, of the Institut de Recherches de la Sidérurgie (IRSID).

In their review[6] of the basic principles of a creep-resisting alloy, Mr. A. Constant and Mr. G. Delbart, of IRSID, summarised the various ways in which alloying elements may act: (1) by raising the temperature of recrystallisation of the base material, the most effective element being that which raises this temperature the most; (2) by the presence of foreign atoms in solid solution in the lattice; (3) by the formation of precipitates of additional phases: carbides, nitrides, or intermetallic compounds.

These authors gave special attention to the part played, in resistance to creep, by fine precipitates of additional phases and the importance of heat-treatment by which the nature, size and distribution of these precipitates could be controlled. In addition to the precipitates originally present before creep occurs, they suggested that precipitates formed in the course of creep by a process analogous to secondary hardening can be most useful in improving creep resistance. The most suitable heat-treatments were investigated for a 0·15 per cent. carbon, 1 per cent. molybdenum, 1 per cent. chromium, 0·2 per cent. vanadium steel to produce structures amenable to secondary hardening under long-term creep conditions. Heating for two hours at 1,050 deg. C. and cooling at a relatively slow rate of 300 deg. C. per hour appeared to be a satisfactory heat-treatment for this steel. In this condition a specimen under a stress of 10·8 tons per square inch at 575 deg. C. had not broken when the test was stopped after 3,200 hours with a creep strain of 6 per cent.

In a paper[7] surveying both theoretical and experimental work concerning the effect of alloying on the creep of metals, Mr. L. A. Rotherham and Mr. L. G. Tottle, of the Department of Atomic Energy, suggested that although much remains to be done, particularly with regard to complex alloys, the relationship between alloying and creep behaviour appeared capable of some degree of prediction already. They also suggested that recent theories, such as were described by Professor A. H. Cottrell[8] concerning the important part played by migration solute atoms in determining resistance to plastic flow, may completely change views previously held concerning complex alloys, in which precipitation was considered to be the primary aid to creep resistance. Instead, it is now thought that for good creep resistance, the prime need is for the right solute atoms to be present and that more than one solute atom may be required to maintain the resistance to creep over the whole range of conditions required. This leads to properly designed " complex " alloys in which changes in metallographic structure, due to variation in composition and/or heat or mechanical treatment, may be secondary effects as regards creep resistance.

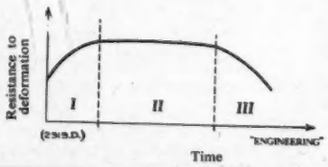
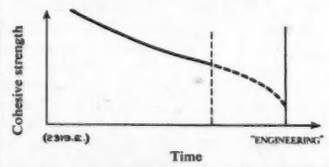
A study of how alloying affects the behaviour

Fig. 1

Fig. 2

Figs. 1 and 2 Bolt steels after creep tests to fracture under 15 tons per sq. in. tension at 525 deg. C; longitudinal sections 0·5 mm. from fractures, × 500. The steel of Fig. 1 fractured after 985 hours, elongation 2·5 per cent., reduction of area 3 per cent.; that of Fig. 2, after 430 hours, elongation 37 per cent., reduction of area 78 per cent.

TABLE I.—Influence of Various Factors on Transcrystalline Flow and the Development of Intercrystalline Cracks

Factor	Transcrystalline Flow	Development of Intercrystalline Cracks
Stress conditions ..	Peak stresses are reduced	No reduction of the peak stresses. (A new peak always present at the end of the crack)
Type of fracture ..	Fracture as a result of neck formation	Brittle fracture
Material	Reduction by : 1. High recrystallisation temperature 2. Precipitation	Reduction by high recrystallisation temperature No reduction by precipitation processes
Dependence on time		
Cold working ..	Reduction	1. Unchanged in stable alloys 2. Increased in unstable alloys
Sigma phase formation	Reduction	Increase

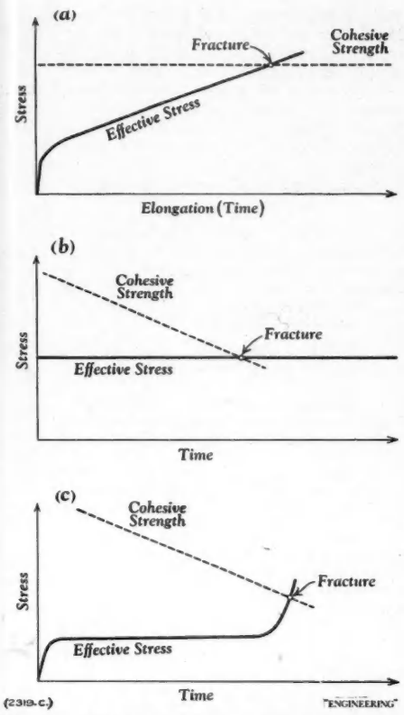


Fig. 3 Basic distinctions between the various methods of material testing. (*a*) Tensile test at room temperature; (*b*) alternating fatigue test; and (*c*) creep test.

of grain-boundary deformation and fracture in creep-rupture tests over a wide range of materials, varying in composition from high-purity aluminium to a complex age-hardenable gas-turbine alloy, was the subject of a paper[9] by Professor N. J. Grant, of the Massachusetts Institute of Technology. He found that, regardless of the purity or degree of alloying, log-stress log-rupture-time, and log-stress log-minimum creep rate curves indicated the tendency to intercrystalline cracking. Plots of true elongation, that is, elongation up to second-stage creep, in general confirmed the incidence of grain-boundary processes indicated by the log-log plots. Further evidence of the extent and nature of grain-boundary deformation and amount of deformation in the grains themselves was obtained by metallographic examination. It was suggested that intercrystalline cracking is, in fact, a matter of relative rates of strain hardening versus recovery processes along the grain boundaries and, further, that the properties of the grain boundary to a certain extent are the properties of the grain, but that imperfections on the boundary permit deformation processes to occur there, preferentially at the higher temperatures.

Mr. I. I. Kornilov, of the Academy of Science, U.S.S.R., in his paper[10] surveyed the results of creep tests which he and his collaborators had made on solid solutions and compounds in various types of metallic systems. From the results of this work he was able to draw some general conclusions on the effect of composition and structure on creep strength. Of special interest was the author's simplified method of making creep tests under stresses caused by centrifugal force during rotation of the specimen; a method which allowed the simultaneous testing of up to 24 specimens.

The contribution of metallographic studies to the understanding of creep mechanism was discussed by Professor J. W. Freeman and Dr. C. L. Corey, of the University of Michigan,[11] and of special significance is the importance they attached to reactions involving carbon, nitrogen and/or oxygen in the mechanism controlling creep. In this respect it is significant that the most useful elements for improving creep resistance such as vanadium, titanium and niobium are all characterised by a very great affinity for carbon and nitrogen and it is probably the solution of these compounds at the higher temperatures and their re-formation as a critical dispersion at the lower temperatures that accounted for their usefulness. Attention was drawn to the notable effect of small amounts of boron applied alone or together with titanium, although in this case the mechanism is less certain and further investigation was desirable. It is also interesting to note that this paper provided some evidence to account for the pronounced effect of small amounts of aluminium (0·006 to 0·02 per cent.) in reducing the creep resistance of a low-carbon steel, reference to which was made by Dr. Allen in his paper. From recent experimental work on a 0·15 per cent. carbon steel it had been shown that creep resistance is primarily a function of the dissolved nitrogen content, the nitrogen combining with the aluminium and being precipitated when the steel is annealed below the coarsening temperature of the austenite.

Dr. C. H. M. Jenkins[12] of the National Physical Laboratory gave an account of some observations made in the course of laboratory studies on third-stage creep and fracture, which was illustrated by a selection of photo-micrographs showing the mode of failure in pure iron, mild steel, 0·5 per cent. molybdenum steels and two nickel-chromium molybdenum steels and a copper-base alloy containing silicon and 3 per cent. of nickel. Examination under the microscope revealed that the mode of deformation is greatly influenced by such changes as hardening by alloy additions, recrystallisation, polygonisation, spheroidisation, age-hardening phase changes and even graphitisation. The gradual onset of the effect of some of these factors, as well as the development of cavities and cracks, leads to tertiary creep. In some specimens the appearance of voids or cavities and their subsequent enlargement may be traced to grain boundaries and would suggest that they are a forerunner of defects which lead to failure. The susceptibility of a material to recrystallise or to soften is important in the suppression of intercrystalline fracture, even though in some cases the cracks may have already been formed.

In a broad way a correlation was found between the reduction in area and degree of elongation in a ruptured specimen, and changes were observed under the microscope for suitable ranges of temperature and stress. For example, low values for reduction in area and elongation were usually associated with intercrystalline cracking as shown in Fig. 1, and, on the other hand, high values for reduction in area and elongation were usually associated with considerable recrystallisation, and free from intercrystalline cracking, but perhaps contained cavities as shown in Fig. 2. Both photo-micrographs are of nickel-chromium-molybdenum steels of somewhat similar composition and cold tensile-strength properties, which were considered for use as a bolt steel for high-temperature service. The steel which behaved as shown in Fig. 1 was the better for this application, especially as its rate of creep, before the minimum rate was reached, was about one-tenth that of the other steel. These differences are ascribed to differences in molybdenum content, melting procedure and nature of the hot-working.

A general discussion of the events leading to intercrystalline failure in essentially single-phase materials was the basis of a paper [13] by Mr. R. Eborall, of the British Non-Ferrous Metals Research Association. He concluded that intercrystalline fracture behaviour may be affected by viscous sliding of the boundaries and by other factors involved in the fracture process itself, as well as by the hardness of the crystals, which has an important effect in raising the local stresses. The fracture characteristics of an alloy may be greatly affected by small alloying additions, improved properties being obtained by adding high melting-point elements of an " unfavourable " size factor.

Dr. R. D. Johnson, Dr. A. P. Young and Dr. A. D. Schwope, of the Battelle Memorial Institute,[14] used X-ray diffraction techniques and the electron microscope to investigate the creep characteristics of high-purity aluminium in the temperature range 204-482 deg. C. under conditions of constant resolved shear stress. The complex nature of the slip bands and the tendency to kinking was observed in single crystals of two different purities. A fine sub-structure. similar to that observed in annealed polycrystalline aluminium, was detected in annealed single crystals of aluminium. This structure has linear dimensions of the order of 1μ, the predicted size of the mosaic structure, and is of importance on theoretical grounds because it raises the question of the distribution of dislocations in the annealed crystals.

DEVELOPMENT OF CREEP-RESISTING ALLOYS

Dr. Allen, in his paper,[1] indicated that the most notable advances in the development of new creep-resisting materials for use at very high temperatures had been in the field of sintered complexes consisting of hard carbides or oxides bonded with metal or alloy. Materials of this type, he stated, had withstood a stress of 2¼ tons per square inch at 1,200 deg. C. for over 900 hours with less than 1 per cent. elongation and 4 tons per square inch at 1,000 deg. C. for a similar period. When it is realised that present-day commercial creep-resisting alloys show a similar behaviour only at the lower temperature of 850 deg. C. this represents a considerable advance in ability to resist deformation. The brittleness of these new materials, however, has so far precluded them from successful application in gas turbines. Further study into the mechanism of flow and fracture in this type of material appears to be well worthwhile, since it may provide useful information for the development of creep-resisting materials. It is also possible that further light on the mechanism of creep resistance at the lower range of temperatures of 250 to 400 deg. C. is given by the behaviour of sintered aluminium powder (SAP) which consists of extremely fine particles of alumina dispersed through a matrix of aluminium. Compared with the best creep-resisting aluminium alloys such as RR.57, SAP shows a marked superiority in creep strength at temperature above 250 deg. C. There is little doubt that the differences in behaviour in this case are due to the fact that the dispersed constituent in SAP is stable at high temperatures, whereas the dispersed hardening constituent in RR.57 alloy, at temperatures above 250 deg. C., first aggregates and then the coarse particles tend to dissolve in the matrix.

To meet the demand for improving gas-turbine compressor materials in the temperature range of 300 to 500 deg. C. interest in recent years had centred on titanium, and a vigorous research is being made for titanium alloys having good strength and satisfactory creep resistance. The interesting feature of this research is the connection between the low elastic modulus of titanium and its creep resistance, and the remarkable effect of the addition of aluminium in raising the elastic modulus and in improving the strength properties of titanium alloys at moderate temperatures.

MECHANISM OF CREEP PROCESSES

The basic principles underlying the creep test and how it differs from other types of tests such as the normal tensile test and the alternating fatigue tests were illustrated by Dr. Siegfried[2] and are shown in Fig. 3. It is seen that there is a fundamental difference between the tensile test and the alternating fatigue test: in the first, the strength of the metal (cohesive strength) as a first approximation, can be considered to remain constant while the load is variable; in the second, the load remains constant but the strength diminishes during the test, fracture occurring when it has been reduced to the level of the stress due to the load. The creep test differs from both of these in that although the total load is kept constant the strain which occurs brings about an increase in stress; the

effective stress is a function of time and runs parallel with the strain, following the course shown in Fig. 3c. This time-strain curve is normally divided into three stages : stage 1 with decreasing rate of creep ; stage 2 with constant rate of creep (strengthening and weakening factors being in equilibrium); and stage 3 with a marked rise in the rate of creep. During this test the strength of the metal falls off continuously, approximately as shown in Fig. 3c. It is clear that in the case of the creep test, conditions are not so simple as in the other tests since we are dealing with time dependent functions.

The symposium revealed in the main two basically different approaches to the study of the mechanism of creep. On the one hand there was the " theoretical " approach, in which the rate-determining processes could be represented by models based on the dislocation theory; and on the other hand the " experimental " approach by which the process of creep is built up from observations of the effects of deformation on the structural and strength characteristics of metals and alloys.

In his paper[15] on "Creep Processes," Dr. W. A. Wood, of the Baillieu Laboratory, University of Melbourne, adopted the latter approach, regarding creep as one aspect of the general problem concerned with why the mechanical properties of metals depend on how it is deformed. The structural changes that occur in the standard tensile test at room temperature were taken as a basis for studying the changes peculiar to slow straining at elevated temperatures (creep). Dr. Wood concluded that the latter process introduces new structural features, described as stress recovery, equilibrium flow and boundary flow. The comparison between the two processes also showed that extension during creep should be divided into two components : boundary flow and grain elongation; recognition of these components simplified such problems as the apparent absence of strain-hardening in creep and the tendency to slipless flow.

Some ideas on the rate-determining process in creep were put forward by Professor N. F. Mott (University of Bristol).[16] After considering current ideas on the nature of work-hardening, he discussed steady-state creep in pure metals and considered how far it was possible to account for some of the facts of creep in terms of the movement of dislocations. He assumed that steady-state creep was due to " slip " and that the process which prevented the dislocations from accumulating in the material and so work-hardening it, is polygonisation as was shown by the experiments of Wood and McLean. Of the two hypotheses put forward to explain polygonisation, namely, " climb " of dislocations and " slip," he concluded that the latter was the more likely, in which case the rate-determining process must be " slip."

Professor J. E. Dorn, University of California, gave a critical analysis of some fundamental experiments at high-temperature creep.[17] He suggested that two alternate mechanisms for creep might exist, one predominant at temperatures above that for rapid crystal recovery (about half of the melting temperature for high-purity metals) and the other, for lower temperatures. While considered to be not the only factor responsible, Professor Dorn showed that higher creep-resistant metals occurred among those transition elements which exhibited the highest activation energies for creep and self-diffusion and that the activation energies for high-temperature creep appeared to agree with that for self-diffusion. From this it was concluded that high-temperature creep is not due to thermal activation of dislocation over a barrier but rather occurs as a result of dislocation " climb " by the self-diffusion process. It was also shown that the activation energy for grain-boundary shearing is practically identical with that for the total creep strain.

Dr. D. McLean (National Physical Laboratory) discussed[18] some experimental data for aluminium and aluminium alloys which led to the fairly firm conclusion that in the case of these metals, the slip process predominates to the virtual exclusion of a diffusion mechanism over the temperature range 200 to 400 deg C. He also showed that the rotation of subcrystals (that is, cells into which the grains split up during creep) is proportional to the elongation, from which it was deduced that practically all the crystal deformation occurred by a normal glide process. Further, the amount of grain-boundary sliding occurring in aluminium and copper during creep was also shown to be proportional to the elongation, suggesting that a linear interaction existed between crystal slip and grain-boundary sliding.

The mechanism of grain boundary displacement and its relation to the creep process as a whole was the subject of a paper[19] by Professor F. N. Rhines (Carnegie Institute of Technology), read by Dr. Epremian, of the American Embassy. This was supported by experimental observations based on the tensile creep behaviour of pure aluminium bicrystals.

The tertiary stage of creep appeared to be more difficult to account for. Dr. C. Crussard and J. Friedel (Institut de Recherches de la Sidérurgie)[5] showed that rupture occurred through the slow formation of intergranular micro-cracks, which is itself caused by some intrinsic mechanism related to the recovery process occurring during creep. The production of an excess of vacancies through the " climb " (diffusion) of dislocations, or the crossing of dislocations of different glide systems was suggested as a possible mechanism.

The processes leading to brittle or ductile fracture were explained by Dr. A. Kochendörfer, of the Max Planck Institut für Eisenforschung, Germany,[20] in terms of the static and dynamic features of dislocations. Suitable arrangements of dislocations were considered to lead to the break-up of the lattice if their energy was greater than the surface energy of the " holes " produced, a hole of this type being equivalent to a crack. A crack of atomic dimensions could be produced by a pile of single dislocations and grow to microscopic dimensions by means of further dislocations, the Griffith mechanism then leading to a brittle fracture. Because of the strong repulsive forces between dislocations of the same sign this was considered only possible if the dislocations were accelerated by the external shear stress to about 90 per cent. of the velocity of sound. It was considered that this happened at normal stresses providing the movement of the dislocation could go on undamped. There was some uncertainty about this but it was assumed to be so. If the conditions for a sufficiently high acceleration of the dislocations were not fulfilled, plastic flow took place followed by ductile fracture. In this case a crack of atomic dimensions was formed by the condensation of vacancies produced by the dislocations, and grew by addition of dislocations until it reached the Griffith length.

Dr. Y. N. Rabotnov (Academy of Science, U.S.S.R.) proposed[21] a mechanical theory of one-dimensional creep in which he aimed to establish mathematically some dependence between stress and strain, giving prime consideration to the essential non-linearity of the process and the non-recoverability of the greater part of the deformation.

A formula for the creep curve which agreed very accurately with the observed curves for Nimonic 80A was given in a paper[22] by Dr. W. Betteridge, of the Mond Nickel Company, Limited, in which he showed that short-period low-stress torsional creep tests, carried out in the course of normal tensile-creep experiments on the material, indicated that the number of available strain-promoting centres increased linearly with the tensile strain resulting from such centres and thus led to the accelerating creep rate known as tertiary creep.

Considering these two methods of approach, namely, " theoretical " and " experimental," it may appear at first sight that they have little in common, but the important outcome of this symposium was that both were leading to a better understanding of creep processes, although much work remained to be done before a mechanism was developed capable of enabling alloys with known creep properties to be designed. In answer to the question of how far we are from this goal, it was suggested by some that it may be five or ten years hence, by others that already creep behaviour was capable of some degree of prediction. Certainly some of the papers revealed how closely the two concepts had approached. In this respect the considerable progress made since 1946 should give great encouragement to all workers in this field.

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[4] The effect of a " V " notch on the tensile creep behaviour of a molybdenum-vanadium steel. R. W. Ridley and H. J. Tapsell (National Physical Laboratory).

[5] Theory of tertiary creep and fracture. C. Crussard and J. Friedel (Institut de Recherches de la Sidérurgie).

[6] Basic principles of a creep-resistant alloy. G. Delbart and A. Constant (Institut de Recherches de la Sidérurgie).

[7] The effect of alloying on the creep of metals. L. A. Rotherham and L. G. Tottle (Department of Atomic Energy).

[8] Creep and ageing effects in solid solutions. A. H. Cottrell (University of Birmingham).

[9] Grain boundary participation in creep deformation and fracture. N. J. Grant (Massachusetts Institute of Technology).

[10] Creep of Solid Solutions and Compounds in Metallic Systems. I. I. Kornilov (Academy of Science, U.S.S.R.).

[11] Metallographic structure and creep. J. W. Freeman and C. L. Corey (University of Michigan).

[12] The relationships of laboratory studies of creep to the behaviour and fracture of materials in high temperature service. C. H. M. Jenkins (National Physical Laboratory).

[13] An approach to the problem of intercrystalline fracture. R. Eborall (British Non-Ferrous Metals Research Association).

[14] Plastic deformation of aluminium single crystals at elevated temperatures. R. D. Johnson, A. P. Young and A. D. Schwope (Battelle Memorial Institute).

[15] Creep processes. W. A. Wood (University of Melbourne).

[16] A Discussion of Some Models of the Rate-Determining Process in Creep. N. F. Mott (University of Bristol).

[17] Some fundamental experiments on high temperature creep. J. E. Dorn (University of California).

[18] Interaction between crystal slip and grain boundary sliding during creep. D. McLean (National Physical Laboratory).

[19] Mechanism of grain boundary displacement. F. N. Rhines (Carnegie Institute of Technology).

[20] A theory of brittle and ductile fracture, with application to creep fracture, based on the dynamical behaviour of dislocations and condensation of vacancies. A Kochendörfer (Max Planck Institute, Düsseldorf, Germany).

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CHEMICAL RESEARCH LABORATORY

Open Days in September

An exhibition of the work in progress at the Chemical Research Laboratory, Teddington, Middlesex, may be seen during a series of " open days," to be held from Tuesday, September 28, to Thursday, September 30. On the first day the hours of opening are 2.30 to 5.30 p.m., and on the Wednesday and Thursday, 10 a.m. to 1 p.m. and 2.30 to 5.30 p.m. Application from industrial firms for invitations to visit the Laboratory should be sent to the Director not later than August 31. Firms already on the mailing list need not re-apply.

THE CHOICE OF OPTIMUM POWER FACTOR

ECONOMIC CONSIDERATIONS FOR THE CONSUMER

By G. P. Cundall, B.SC., A.M.I.E.E.*

The total power (kVA) in an alternating current circuit is the vector sum of two components at right angles, the active power (kW) and the reactive power (kVAr), the ratio kW/kVAr being defined as the power factor. The active power is a measure of the work done in the production of mechanical effort or heat. The reactive power does no work, but creates the magnetic field in the windings of inductive machinery. When charging for electricity consumption the Supply Authority usually measures only the active power consumed in kilowatt-hours but, because the generation, transmission and distribution equipment has to be large enough to carry the total power in the circuit at peak periods, a maximum demand charge either for kVA, or dependent on the power factor in some other way, is also usually made.

ECONOMIC LIMIT OF RETURN

It is fairly generally known that under certain tariffs the cost of electricity can be reduced by improving the power factor. The extent to which improvement should take place, however, often poses a problem; and it is in an attempt to solve it that this article has been written.

Power factor values of 0·9 or even 0·8 are considered by some to be adequate, whereas the text-book formula for the economic limit, where there is a kilovoltampere tariff, usually gives a value of over 0·99. As far as the author is aware no formula has been derived for finding the economic limit under a kilowatt tariff. One is therefore given here.

At the economic limit the return on the last pound spent is nil so improvement to a lower value is more desirable. Power factor improvement should be looked upon as an investment, for at the optimum value not only is the average return on capital good, but also that on the last pound spent.

Of the various corrective equipment available only capacitors are referred to, although the general argument advanced applies to all kinds.

Capacitors improve the power factor by generating reactive power. They are rated in kVAr and produce their output merely by the application of their rated voltage. Their own consumption of electricity is extremely small, that of a high quality capacitor being only about 1·5 watts per kVAr.

THE NATURE OF THE INVESTMENT

Power factor improvement should be looked upon as an investment which is special in that it consists of two opposing factors; firstly an income brought about by the saving in the cost of electricity, and secondly an expenditure incurred by the overheads chargeable to the capacitors. As the power factor is improved this income and expenditure rise at different rates, the difference between which depends on the tariff in force.

There are two principal kinds of tariff. The simpler imposes a charge for each kilovolt-ampere of maximum demand so that for a given kilowatt load it is inversely proportional to the power factor. The other imposes a charge for each kilowatt of maximum demand together with a power factor variation charge. This variation is usually arranged to offer equal savings for equal steps of improvement above some chosen figure.

The overhead charges on capacitors include depreciation, interest on capital, electrical losses and maintenance costs. Of these by far the most important are the first two, the others being very small. The usefulness and efficiency of capacitors remain virtually constant throughout their life of about 20 years or more, so that it is reasonable to depreciate them by a fixed annual instalment of about 5 per cent. The capital expended will probably incur an interest charge a little higher than the Bank rate. Money set aside for depreciation will itself earn interest and over the life of the capacitors this interest will probably about offset the maintenance and loss charges. Generally an overhead allowance of 10 per cent. of the estimated installed cost of the capacitors should be satisfactory.

* Mr. Cundall is with British Insulated Callender's Cables, Limited.

OPTIMUM POWER FACTOR

The overhead charges are directly proportional to the amount of capacitance installed, but this proportionality does not apply to the savings because successive equal amounts of capacitance increase the power factor in unequal steps. The increment by which the power factor is increased by a unit of capacitance is greatest in the region 0·82 to 0·83, as shown in Fig. 1. From this it is easy to see that for a kilowatt tariff which offers equal savings for equal steps of improvement the greatest rate of return on the total capital expended will be obtained by improving the power factor to about 0·83. This is independent of the original power factor. In the case of a kilovoltampere tariff there is no power factor which offers the maximum rate of return because each reactive kilovoltampere generated reduces the active kilovoltamperes by a less amount than the previous one.

Whichever tariff is in force a power factor is reached where the overheads chargeable to an additional reactive kilovoltampere of capacitance become equal to the saving obtainable by it from the tariff. This point is defined in several text books as the economic limit but, although it may yield a reasonable rate of return on the whole sum invested, that on the last pound spent is nil.

As a result, improvement to such a high value does not represent the best possible investment. In the best investment the lowest rate of return on any part is desirable. The optimum power factor therefore might be defined as that at which the return on the last pound spent is acceptable. At this value the average return will, of course, be better than that at the economic limit. Alternatively, the optimum power factor may be considered to be that at which, after allowing for capital and depreciation charges, the greatest possible saving is yielded in a given period. In this case the rate of return on the last pound spent is the reciprocal of the number of years in the chosen period.

TABLE I.—*Formulæ for Calculating Optimum Power Factor*

Requirement	For a kVA Tariff	For a kW tariff
Optimum value	Power factor = $\cos\left\{\text{arc sin}\left(\frac{rK+C}{A}\right)\right\}$	Power factor = $f_0\left\{\left(\frac{rK+C}{Bp}\right)\right\}$
Economic limit	Power factor = $\cos\left\{\text{arc sin}\left(\frac{C}{A}\right)\right\}$	Power factor = $f_0\left(\frac{C}{Bp}\right)$

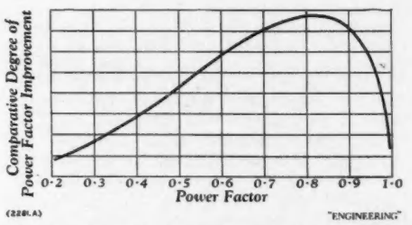

Fig. 1 Curve showing the increment by which the power factor is increased for each unit of capacitance.

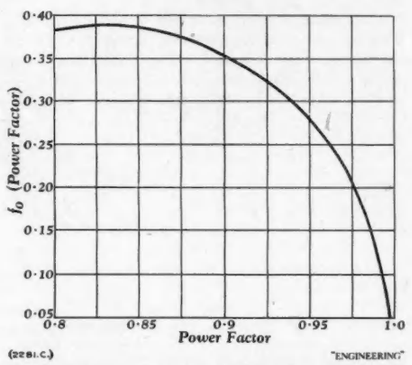

Fig. 2 Curve showing the relationship of the multiplying function, f_0, to the power factor in a kilowatt-hour tariff.

FORMULÆ FOR CALCULATING POWER FACTOR

The formulæ given in Table I enable the optimum power factor and the economic limit of improvement to be calculated for any kind of tariff.

100 r is the percentage rate of return required on last pound spent; K, the estimated installed cost of capacitors and control gear in pounds per kVAr; C, the estimated annual overhead charges in pounds per kVAr; A, the annual charge of last kVA of maximum demand in pounds; B, the annual average charge per kilowatt of maximum demand in pounds; p, the percentage by which the kilowatt demand charge is varied for each 0·01 by which the power factor differs from a fixed value; and f_0 is a function which is plotted in Fig. 2.

The value of K (and C, which will be a percentage of it) will depend on the scheme chosen and this scheme will be governed by both technical and economic considerations. The initial estimate can be checked by costing a scheme of correction to the power factor given by it and re-valuing it if necessary.

An example will illustrate the use of the formulæ and also serve to demonstrate the effects of improvement to various values. Suppose there is a load of 432 kW at 0·6 power factor, which is 720 kVA, and that in the first case the tariff makes the following demand

TABLE II.—Effects of Improving the Power Factor of a 432-kW Load from 0·6 to Various Higher Values

New Power Factor	Cost of Improvement, Pounds	kVA Tariff			kW Tariff		
		Annual Saving, Pounds	Return on Last Pound, Per Cent.	Return After Ten Years, Pounds	Annual Saving, Pounds	Return on Last Pound, Per Cent.	Return After Ten Years
0·8	1,200	600	40	4,800	452	43	3,320
0·9	1,735	806	36	6,325	541	14	3,675
0·946	2,050	895	23	6,900	576	10	3,710
0·983	2,350	945	10	7,100	598	1	3,630
0·986	2,390	946	8	7,070	599	Nil	3,600
0·9955	2,535	951	Nil	6,975	597	−10	3,435
Unity	2,740	946	−10	6,720	584	−16	3,100

charges: the first 200 kVA at £6 per kilovolt-ampere per year, the next 300 kVA at £5 per kilovoltampere per year, and the rest at £4 per kilovoltampere per year ; and that in the second case the charges are: the first 160 kW at £7·5 per kilowatt per year, the next 250 kW at £6·25 per kilowatt per year, and the rest at £5 per kilowatt per year. The total demand charge is to be increased by 1 per cent. for each 0·01 by which the power factor is less than 0·8 and decreased by ½ per cent. for each 0·01 by which it exceeds 0·8. It is further supposed that the installed cost (K) of capacitance will be £4·75 per kVAr and that the annual overhead charges (C) will be 10 per cent. of this.

The value to be substituted for A in the formulæ must be the price of the last kilovolt-ampere of demand and if the solution gives a power factor which would alter this, the equation must be resolved using the new value. For instance, if in the example quoted, a return of 10 per cent. were required on the last pound spent, the substitution of the value A equals 4 in the first equation in Table I would give a power factor of approximately 0·97, which would reduce the load to 446 kVA and alter the price of the last kilovolt ampere to £5. A value of A equal to 5 should therefore be used when the correct power factor of approximately 0·983 will be found.

The value to be substituted for B must be the average charge per kilowatt of demand, which, of course, is independent of the power factor. In the case quoted it would be £2,860 divided by 432 which is £6·62. The value of p used must be that which is applicable at the final power factor.

For the example quoted the effects of improvement to different values are given in Table II. It has been assumed that the optimum power factor is that which yields 10 per cent. return on the last pound spent.

The tariffs are comparable in that the charges at 0·8 power factor would be the same, £2,860, in each case. It will be noted from the table, however, that much greater savings are possible under the kilovoltampere tariff and that for it, in particular, those yielded at 0·8 and 0·9 power factor are well below the best possible.

For the chosen optimum condition of 10 per cent. return on the last pound spent the power factors for the kilovoltampere and kilowatt tariffs are 0·983 and 0·946. At these values greater savings are obtained in 10 years than are possible at any other power factors after deducting capital and overhead charges. The annual savings obtainable at the economic limits of 0·986 and 0·995 power factor would be very little greater, but the extra cost of capacitance would be considerable. Beyond the economic limit the annual saving will be seen to fall.

CONCLUSION

Where the supply authority's tariff encourages the maintenance of a high power factor it is usually economic for the consumer to take steps to attain it. There is, however, a limit to the extent to which it is desirable to make improvements and the problem should be treated as an investment on the lines indicated. Owing to the variations in costs and tariffs, generalisation is difficult, but as a rule a kilovoltampere tariff encourages improvement to higher values more than does a comparable kilowatt tariff. In each case the best power factor is likely to be between 0·90 and 0·98.

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INDEX TO "ENGINEERING"
Volume 176 now ready

The Index to Volume 176 of ENGINEERING (July-December, 1953) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher, 35 and 36 Bedford-street, London, W.C.2. Any reader wishing to receive regular copies of the Index as they are published can apply to be put on the mailing list. Those already on the mailing list need not re-apply.

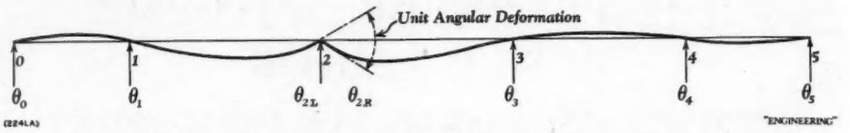

Fig. 1 Typical five-span beam with unit angular distortion impressed at the second support.

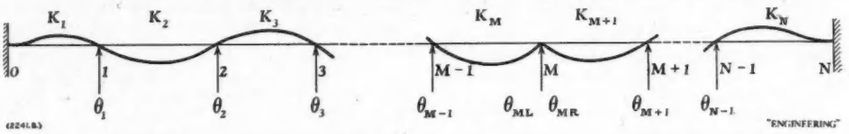

Fig. 2 Multi-span continuous beam with unit distortion impressed at an intermediate support.

INFLUENCE LINES FOR CONTINUOUS BEAMS

UNIT ORDINATES TABULATED

By E. Markland

The problem of finding influence lines for any bending moment, shear force, or reaction in a continuous beam may be solved by finding the deflected shape of the beam when unit distortion, corresponding to the required action, is impressed on the beam. As influence lines for moments at supports may readily be used, by the principles of statics, to obtain influence lines for all other moments and forces, much work has been directed to devising rapid methods for finding the deflected shape when a unit angular distortion is imposed at a support. Grinter,[1] for example, gives a method of successive approximation, while Coates[2] finds the influence line for spans adjacent to the support in question by use of modified stiffness factors.[3]

If unit angular distortion is impressed at an intermediate support of a beam continuous over n spans, and freely supported at its extremities, there are $(n + 2)$ initially unknown rotations at supports, so that a solution involves the same number of simultaneous equations. For the five-span beam of Fig. 1, for instance, there are seven rotations to be found in order that the deflected shape, or the influence line, may be drawn. It is, however, unnecessary to solve the seven equations simultaneously; by working from each end of the beam, as indicated below, a simple solution, involving only two simultaneous equations, is obtained.

Consider the beam, encastré at its ends 0 and N, continuous over n spans, of Fig. 2. Each span is assumed to have constant flexural rigidity along its length, so that if a unit distortion is imposed at any intermediate support M, the slope-deflection equations may be written:—

$$\left.\begin{aligned} 2K_1(2\theta_1) + 2K_2(2\theta_1 + \theta_2) &= 0 \\ 2K_2(2\theta_2 + \theta_1) + 2K_3(2\theta_2 + \theta_3) &= 0 \\ 2K_3(2\theta_3 + \theta_2) + 2K_4(2\theta_3 + \theta_4) &= 0, \text{ etc.} \end{aligned}\right\} \quad (1)$$

where θ is the slope at the support indicated by the subscript and K has its conventional signi-

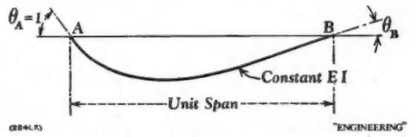

Fig. 3 Dimensions of the elementary span for Table I, below.

TABLE I.—UNIT INFLUENCE LINE ORDINATES
(*For definitions, see Fig. 3 above*)

$\frac{-\theta_B}{\theta_{AA}}$	Fraction of span measured from A								
	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9
0 Fixed	0·0810	0·1280	0·1470	0·1440	0·1250	0·0960	0·0630	0·0320	0·0090
0·10	0·0819	0·1312	0·1533	0·1536	0·1375	0·1104	0·0777	0·0448	0·0171
0·11	0·0820	0·1315	0·1539	0·1546	0·1388	0·1118	0·0792	0·0461	0·0179
0·12	0·0821	0·1318	0·1546	0·1555	0·1400	0·1133	0·0806	0·0474	0·0187
0·13	0·0822	0·1322	0·1552	0·1565	0·1413	0·1147	0·0821	0·0486	0·0195
0·14	0·0823	0·1325	0·1558	0·1574	0·1425	0·1162	0·0836	0·0499	0·0203
0·15	0·0824	0·1328	0·1565	0·1584	0·1438	0·1176	0·0851	0·0512	0·0212
0·16	0·0824	0·1331	0·1571	0·1594	0·1450	0·1190	0·0865	0·0525	0·0220
0·17	0·0825	0·1334	0·1577	0·1603	0·1463	0·1205	0·0880	0·0538	0·0228
0·18	0·0826	0·1338	0·1583	0·1613	0·1475	0·1219	0·0895	0·0550	0·0236
0·19	0·0827	0·1341	0·1590	0·1622	0·1488	0·1234	0·0909	0·0563	0·0244
0·20	0·0828	0·1344	0·1596	0·1632	0·1500	0·1248	0·0924	0·0576	0·0252
0·21	0·0829	0·1347	0·1602	0·1642	0·1513	0·1262	0·0939	0·0589	0·0260
0·22	0·0830	0·1350	0·1609	0·1651	0·1525	0·1277	0·9953	0·0602	0·0268
0·23	0·0831	0·1354	0·1615	0·1661	0·1538	0·1291	0·0968	0·0614	0·0276
0·24	0·0832	0·1357	0·1621	0·1670	0·1550	0·1306	0·0983	0·0627	0·0284
0·25	0·0833	0·1360	0·1628	0·1680	0·1563	0·1320	0·0998	0·0640	0·0293
0·26	0·0833	0·1363	0·1634	0·1690	0·1575	0·1334	0·1012	0·0653	0·0301
0·27	0·0834	0·1366	0·1640	0·1699	0·1588	0·1349	0·1027	0·0666	0·0309
0·28	0·0835	0·1370	0·1646	0·1709	0·1600	0·1363	0·1042	0·0678	0·0317
0·29	0·0836	0·1373	0·1653	0·1718	0·1613	0·1378	0·1056	0·0691	0·0325
0·30	0·0837	0·1376	0·1659	0·1728	0·1625	0·1392	0·1071	0·0704	0·0333
0·31	0·0838	0·1379	0·1665	0·1738	0·1638	0·1406	0·1086	0·0717	0·0341
0·32	0·0839	0·1382	0·1672	0·1747	0·1650	0·1421	0·1100	0·0730	0·0349
0·33	0·0840	0·1386	0·1678	0·1757	0·1663	0·1435	0·1115	0·0742	0·0357
0·34	0·0841	0·1389	0·1684	0·1766	0·1675	0·1450	0·1130	0·0755	0·0365
0·35	0·0842	0·1392	0·1691	0·1776	0·1688	0·1464	0·1145	0·0768	0·0374
0·36	0·0842	0·1395	0·1697	0·1786	0·1700	0·1478	0·1159	0·0781	0·0382
0·37	0·0843	0·1398	0·1703	0·1795	0·1713	0·1493	0·1174	0·0794	0·0390
0·38	0·0844	0·1402	0·1709	0·1805	0·1725	0·1507	0·1189	0·0806	0·0398
0·39	0·0845	0·1405	0·1716	0·1814	0·1738	0·1522	0·1203	0·0819	0·0406
0·40	0·0846	0·1408	0·1722	0·1824	0·1750	0·1536	0·1218	0·0832	0·0414
0·5 Pinned	0·0855	0·1440	0·1785	0·1920	0·1875	0·1680	0·1365	0·0960	0·0495

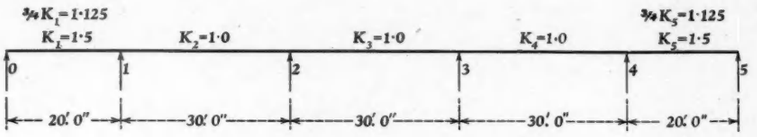

Table of End Rotations

Working from Left	1	−4·25	16·00	−59·75
Working from Right	−59·75	16·00	−4·25	1

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Fig. 4 Worked example: a five-span continuous beam with pinned end supports.

ficance of $\frac{I}{l}$, that is, the second moment of area of the section divided by the length of the particular span. Working from the left-hand support, all rotations at supports, up to and including θ_{ML}, may then be expressed in terms of θ_1, by use of this sequence which follows from equations (1):—

$$\left.\begin{aligned}\theta_2 &= -2\left(1+\frac{K_1}{K_2}\right)\theta_1 \\ \theta_3 &= -2\left(1+\frac{K_2}{K_3}\right)\theta_2 - \frac{K_2}{K_3}\theta_1 \\ \theta_4 &= -2\left(1+\frac{K_3}{K_4}\right)\theta_3 - \frac{K_3}{K_4}\theta_2, \text{ etc}\end{aligned}\right\}. \quad (2)$$

Similarly, working from the right-hand support, all end-rotations up to and including θ_{MR} may be expressed in terms of a single θ. By setting $(\theta_{MR} - \theta_{ML})$ equal to unity, and writing the equation of equilibrium at support M, both these rotations are found, and the rest follow by proportion from the sequences already calculated. If the end of the beam is simply supported instead of encastré, it is necessary only to write $\frac{3}{4}$ K in place of K in the end span.

A numerical example illustrates the simplicity of the procedure. Consider the 5-span beam of Fig. 4, for which it is desired to obtain influence lines for each of the support moments in turn. The sequence of rotations in equations (2) are (with $\theta_1 = 1$):—

$$\theta_2 = -2\left(1+\frac{1\cdot125}{1\cdot0}\right)(1) = -4\cdot25$$

$$\theta_3 = -2\left(1+\frac{1\cdot0}{1\cdot0}\right)(-4\cdot25) - \frac{1\cdot0}{1\cdot0}(1) = 16\cdot0$$

$$\theta_4 = -2\left(1+\frac{1\cdot0}{1\cdot0}\right)(16\cdot0) - \frac{1\cdot0}{1\cdot0}(-4\cdot25) = -59\cdot75.$$

These values are entered below the appropriate supports in Fig. 4, and indicate that if a rotation is made at any support of the beam, then the slopes at all supports to the left of it are proportional to these values. In a similar manner a set of values is obtained by working from the right-hand end of the beam.

The influence line for moment at support 2, for instance, may now be found by distorting the beam at this support so that

$$\theta_{2R} - \theta_{2L} = 1. \quad . \quad . \quad (3)$$

Now the rotation at support 1 will be $-\left(\frac{1}{4\cdot25}\right)\theta_{2L}$ and the rotation at support 3 will be $-\left(\frac{4\cdot25}{16}\right)\theta_{2R}$ so that slope-deflection equations give, as the condition of equilibrium at support 2,

$$2\times1\cdot0\left(2\,\theta_{2L} - \frac{1}{4\cdot25}\,\theta_{2L}\right) + 2\times1\cdot0\left(2\,\theta_{2R} - \frac{4\cdot25}{16}\,\theta_{2R}\right) = 0$$

or

$$1\cdot765\,\theta_{2L} + 1\cdot733\,\theta_{2R} = 0. \quad . \quad (4)$$

From equations (3) and (4):

$$\theta_{2R} = 0\cdot504 \text{ and}$$
$$\theta_{2L} = -0\cdot496.$$

All other rotations at supports follow immediately by proportion from the values already found, and are shown on Fig. 5, which also gives the solution for the shape of the influence line at support 1.

It now remains to find the ordinates of the influence line in each span. Although this is perfectly straightforward, the use of Table I saves the major part of the arithmetic. For a span of unit length, the deflection at any fraction of the span when unit rotation is applied at one end and a known rotation at the other may be read from the Table directly, so for a span of length l feet, with an end-rotation of θ in place of unity, influence line ordinates are obtained in units of feet by multiplying by $l\,\theta$.

For span 2 – 3 of the example, where

$l = 30$ ft.

$\theta_2 = 0\cdot504$ (the larger end-rotation)

$\theta_3 = -0\cdot134$ (the smaller end-rotation)

$\frac{\theta_3}{\theta_2} = -0\cdot266$

and

$l\,\theta_2 = 15\cdot1$ ft.,

at the following fractions of the span, measured from 2, the influence line ordinates are:—

At 0·1 span: $15\cdot1\times0\cdot0834 = 1\cdot26$ ft.

At 0·2 span: $15\cdot1\times0\cdot1365 = 2\cdot06$ ft.

At 0·3 span: $15\cdot1\times0\cdot1638 = 2\cdot47$ ft., etc.

The complete influence lines, deduced in this way from the end-rotations of Fig. 5, are given in Fig. 6.

One further point calls for comment. If a large number of spans is involved, the sequence of end-rotations will lead to numbers very much larger than the starting values used at the extremity of the spans, and the question arises as to whether appreciable error would be introduced if the calculations were simplified by starting at, say, three supports away from the one at which the influence line is required. The very small effect of ignoring spans beyond the third or fourth from the support in question may be seen from Table II; it is clear that for most purposes the effect of spans beyond the fourth is quite negligible.

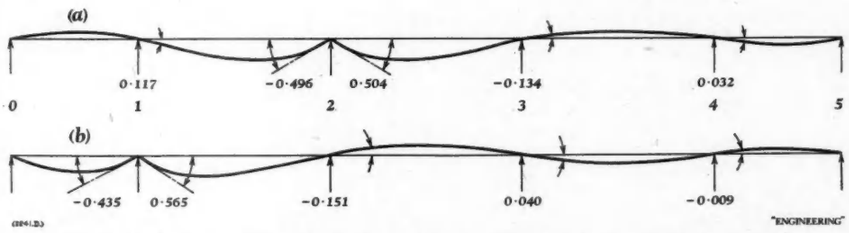

Fig. 5 Rotations at supports when unit rotations are applied at (a) support 2, (b) support 1.

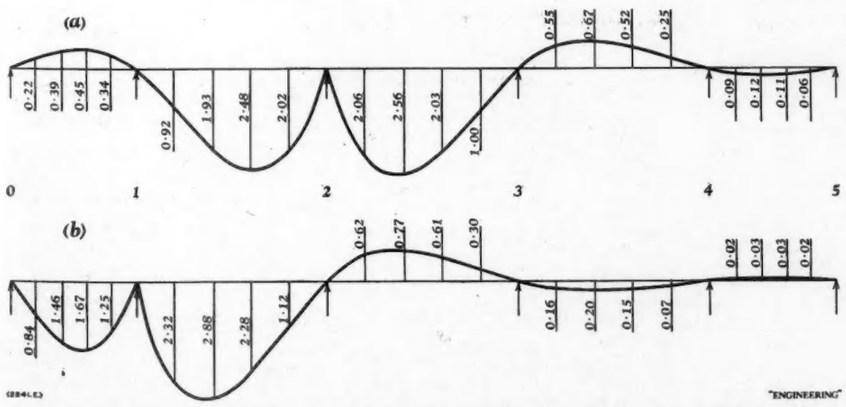

Fig. 6 (a) Influence lines for support 2, (b) for support 1, of the worked example of Fig. 4, above.

TABLE II.—*End-Rotations at Each Support for 3- and 4-Span Beams with the remote end either Pinned or Encastré*

Support No.	0	1	2	3	4
End 3 pinned ..	1·000	−0·269	0·077	−0·039	—
End 3 encastré ..	1·000	−0·267	0·067	0·000	—
End 4 pinned ..	1·000	−0·268	0·072	−0·021	0·010
End 4 encastré ..	1·000	−0·268	0·071	−0·018	0·000

Spans 01, 12, . . . are equal, and unit rotation is applied at end 0.

REFERENCES

[1] Grinter, L. E., *Theory of Modern Steel Structures*, vol. II, art. 143.

[2] Coates, R. C., "Influence Lines for Support Moments in Continuous Beams," ENGINEERING, page 230, vol. 172 (1951).

[3] Grinter, L. E., *Theory of Modern Steel Structures*, vol. II, art. 116.

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INSPECTING WIRE-DRAWING DIES

In order to demonstrate the use and qualities of the "Profiloscope" – an instrument for examining wire-drawing dies by optical reflection – a mobile exhibition is to tour the Midlands. The Profiloscope, which was developed by B.I.S.R.A., was described in ENGINEERING, on page 621, vol. 175 (1953).

REHEAT FROM ANOTHER VIEWPOINT

TWO STAGES WITH HEAT TRANSFER BY INTERMEDIATE FLUID

By I. Lubbock, M.A. (CANTAB.), M.I.MECH.E.

It is instructive to examine reheat as exemplified by the modern reheat-unit boiler and steam turbine for base-load power plants. The recent description[1] of the Dunston "B" generating station created considerable discussion but, owing to the low pressure of 600 lb. per square inch chosen for this plant, it was not easy to draw comparisons between the exact thermodynamic gain obtained from reheat in this case and the calculated data for the many large reheat-unit boilers now installed or proposed in the U.S.A.

A review of the thermodynamic principles involved is justified since after about 25 years of discontinuous development, many improved reheat units are being built in the United States. Among the best examples are the Philip Sporn 150-MW units[2] of 1948 and four 217-MW units[3] completed in 1952. The 150-MW units, which operate at a pressure of 2,000 lb. per square inch and a temperature of 1,050 deg. F. with reheat to 1,000 deg. F., have a heat rating of 9,270 B.Th.U. per kWh generated; and the 217-MW units, working at a pressure of 2,000 lb. per square inch and a temperature of 1,050 deg. F. with reheat to 1,050 deg. F., use heat at a rate of 9,000 B.Th.U. per kWh.

Theoretically it is not easy to explain the operation of reheat and it was not at all surprising to discover, during the discussion on the Dunston "B" Station, that some people still consider it contrary to the laws of thermodynamics. This doubt arises from the fact that, although heat should be supplied at the highest possible temperature, it seems at first sight questionable advantage to add heat to the cycle for a lower pressure drop than that obtained by supplying heat at the top pressure.

REHEAT AND NEW MATERIALS

It is still more curious that such an authority as J. K. Salisbury[4] writing in 1950 should refer to reheat as a temporary measure to be adopted until increases in the pressures and temperatures permissible will enable single-stage expansion to enter the lead again. The possibility of metallurgical developments leading to any important advance on superheat temperatures of 1,100 deg. F. at 2,000 lb. per square inch and higher is slight, even with columbium-stabilised austenitic steels and neglecting conditions imposed by turbine-rotor and blade properties for these temperatures and pressures.

It is well known that the open-cycle gas turbine can be built for industrial applications – as distinct from aircraft propulsion – to operate at say 1,300 deg. F. or even 1,400 deg. F. It is also entirely possible that, with blade and rotor cooling, the open-cycle gas turbine may operate one day at between 1,800 deg. F. and 2,000 deg. F., but it is far less plausible to envisage such temperatures in a closed cycle, with the walls of superheater tubes at a suitable differential temperature for heat transference. The gas turbine also has the advantage of moderate cooling at the entry stages by lower-temperature compressor air, and although this is not impossible on a steam cycle, modifications would be required.

It will still be apparent from what follows therefore that reheat will again be justified, even if allowance is made for the possibility of higher temperatures and pressures in the steam cycle.

CYCLE EFFICIENCY WITH REHEAT

There are several ways of showing the manner in which reheat operates in relation to the cycle, and the outstanding exposition was given in the paper by Blowney and Warren[5] in 1925. These authors established clearly how the thermodynamic gain could be calculated and, what is of great importance, showed that this gain had an optimum value at about 30 per cent. of the adiabatic heat drop. In this paper the authors also indicated, however, that purely on the theoretical isentropic heat drop with 100 per cent. turbine efficiency the gains diminished rapidly with increasing pressures. The fact that their later curves gave an increasing advantage with higher pressures is due entirely to the suppression of wetness losses coupled with the effect of the reheat factor for any given stage efficiency of the turbine. The wetness loss was taken at the well-known figure of 1·15 per cent. decrease in stage efficiency for each 1 per cent. of wetness in the steam, but the reheat factors as given in the paper are not sufficiently comprehensive at pressures below 100 lb. per square inch.

ADDITIONAL REHEAT STAGES

Another outstanding contribution to the theory of reheat given by Blowney and Warren was a demonstration of gains added when more than one stage of reheat was employed, and this point will be dealt with in greater detail in what follows.

The effect of regenerative feed heating was calculated by these authors to be practically additive, but this point has not yet been fully explained particularly in respect of the correction to be allowed. It is clear, of course, that the thermal gain calculated with respect to the reheated steam should be reduced to the value of the total stop-valve steam but it is difficult to assess the increase in feed-water temperature due to the bled steam being at a higher temperature as a result of reheat. The net result can only be obtained by study of a particular case and by a readjustment of the feed-heater quantities in the light of any assumed reheat.

A more recent exposition of the subject, still substantially on the lines adopted by Blowney[6] and Warren, was given by Harris and White, who considered, however, typical cases of regenerative-feed-heat distribution and still showed gains of about 6 per cent., which are approximately those of the original authors, although they are slightly reduced on account of the feed-heating effect. They also take into account the reductions due to pressure drop in the reheater and the usual turbine-leaving loss.

R. L. Reynolds indicates[7] rather greater drops as a result of feed heating and consequently points out the shift in the optimum point of reheat.

THE PRESSURE/TOTAL HEAT DIAGRAM

In the present paper the pressure/total heat diagram used by refrigeration engineers is recommended since it gives a clearer picture of the reheat process. The constant entropy lines become curved and it is the divergence of these lines with increasing temperature in the superheat region that suggests an explanation of the effects obtained. In physical terms it demonstrates that the expansion properties of steam as a working substance change markedly as the temperature increases, and this is to be expected since it is approaching the state of a fixed gas as distinct from a saturated vapour.

With the aid of Figs. 1 and 2 it is possible to follow the effects of reheat for one or two stages. Neither diagram is drawn to scale but Fig. 2 is substantially similar in configuration to accurate curves plotted from steam tables.

In Fig. 1, steam initially at B and which is assumed to be entirely at 2,015 lb. per square inch

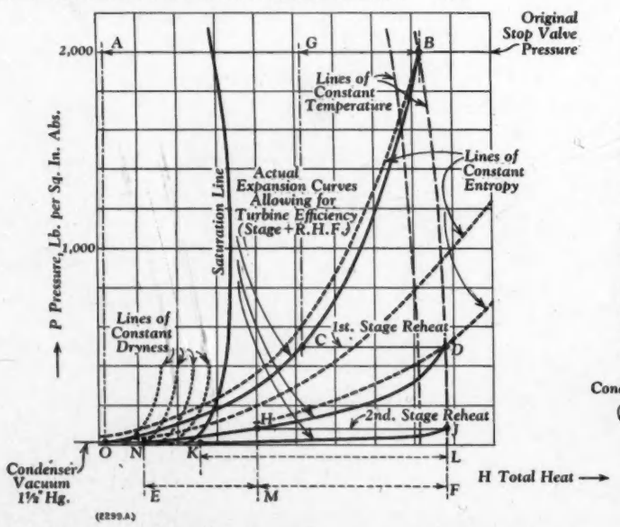

Fig. 1 The operation of reheat in one or two stages is illustrated by a graph relating steam pressure and total heat during a cycle.

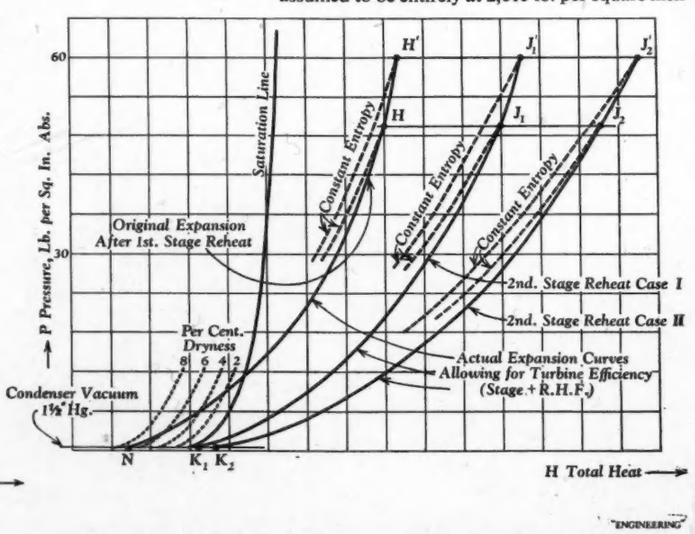

Fig. 2 Second-stage reheat shown on an enlarged pressure/total heat diagram. Both reheats should be performed near the maximum temperature of the cycle.

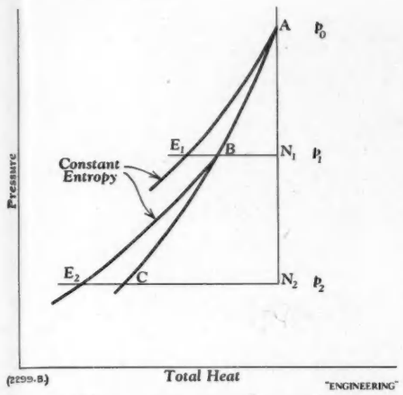

Fig. 3 To determine the average reheat factor between any two points the actual expansion curve is plotted by means of this construction.

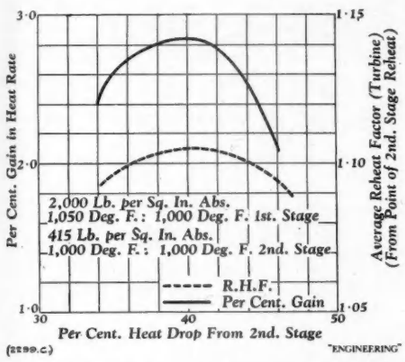

Fig. 4 By superimposing a theoretical second stage of reheat on an existing plant, the results shown in the table and plotted here were obtained.

absolute, is expanded to C, where the first stage of reheat is applied bringing the total heat to the point D. The dotted line alongside BC is the constant entropy line from B which crosses the saturation line and passes through the lines of constant dryness to the condenser pressure (1·5 in. of mercury) to give a dryness of 0·775. The actual expansion curve allowing for stage efficiency (80 per cent.) and reheat factor (1·04) has its end point at O where the dryness is 0·883.

Similarly, in the expansion from D, the dotted line is the constant-entropy line and if allowance is made for stage efficiency and reheat factors, the end point is N with a dryness of 0·94.

It is obvious that the heat drop for single-stage operation without reheat is AB, the extra heat received is CD and the extra work done in the cycle is EF less AG.

TWO STAGES OF REHEAT

Similarly, if a second stage of reheat is carried out at H to bring the total heat to J, the end point of the expansion from J is then K, and the extra work done is the difference between KL and EM for an extra heat addition of HJ.

Unfortunately it is not possible to read the figures off prepared charts, since, as in the case of the normal total heat/entropy diagram, the reheat factors have to be calculated stage by stage, but a glance at the general trend of the isentropic curves will reveal that in a large number of trial intersections a definite gain of overall thermal efficiency is obtained. On the isentropic lines alone, the gain becomes progressively smaller with higher initial pressures, but when turbine efficiency, reheat factor and correction for improved dryness is taken into account the results are illuminating and confirm the findings of the papers previously quoted.

SUCCEEDING STAGES OF REHEAT

For reasons which will be dealt with in greater detail later, interest in succeeding stages of reheat has remained almost completely academic since Blowney and Warren[5] showed that further gains in efficiency were obtainable by continuing the process. The possibility of achieving any thermal gain appears at first sight to be doubtful, and the author felt compelled to take a known example of single reheat and work through the expansions stage by stage to discover how the improvement occurs. The curves of Blowney and Warren certainly showed decreasing returns, but with an 8 per cent. improvement for reheat at a single stage it seemed quite good to be able to obtain another 4 per cent. with a second stage (initial pressure, 1,000 lb. per square inch).

Heat is now being absorbed at what would appear to be an absurdly low pressure in the cycle and, what is more, most of the advantage of eliminating wet steam has already disappeared as a result of the first reheat. At the end of the cycle considerable superheat might certainly be expected and also a gain of work, but at a lower efficiency than that of the rest of the cycle. The calculated figures given below are again illuminating since they indicate that the progressive inclination (on the pressure/total heat diagram) of the constant entropy lines, provides so strong a tendency for the expansion to end in the saturation zone that the balance still remains on the right side.

OPTIMUM TEMPERATURES

It is almost self-evident from the fact that a second stage of reheat still improves the cycle that first stage reheat should be carried out to as near the maximum temperature of the cycle as possible, and that nothing can be gained for this first stage by choosing a lower temperature of reheat. It is interesting to inquire, however, whether this still applies to succeeding stages, when the increasing residual superheat is taken into account.

It is found that even for the second stage the best result is obtained at the full reheat temperature. Fig. 2 indicates the method used with the pressure/total heat diagram at the low pressures of the second stage. The curves carry similar lettering to those in Fig. 1, where the second stage expansion JK is dwarfed by the scale and becomes J_1K_1, J_2K_2, etc., in Fig. 2.

In Fig. 3 is given the construction for plotting the actual expansion curve stage by stage which determines ultimately the average reheat factor between any two points. Thus if we start with a pressure p_0 represented by A in Fig. 3, the isentropic line AE_1 cuts the stage pressure p_1 at E_1 so that E_1N_1 is the adiabatic heat drop for that stage. We now set off E_1B to represent the stage-efficiency loss assumed. Thus if we take a stage efficiency of 80 per cent., E_1B is 0·20 times E_1N_1. We repeat the process for the next stage from p_1 to p_2, E_2C being in this case 0·20 times E_2N_2. The actual expansion curve is therefore ABC.

SECOND STAGE REHEAT BY INTERMEDIATE FLUID

It has taken about 25 years, in the face of the obvious constructional difficulties of piping steam from the turbine to the boiler and back again, to develop the application of one stage of reheat to its present form. It has been conceded that for a second stage with the very much larger-bore piping necessary, such a method would be almost out of the question. The chief alternative proposed so far has been the use of live steam but the reheat point is the saturated temperature and calculations show very reduced gains. In fact for a modern high-pressure high-superheat system, reheat of this magnitude for a second stage would give little or no gain. This will be demonstrated in the calculated results given below for such a power plant.

It is because the author considers a second stage of reheat to be feasible by means of a circulating intermediate fluid or gas that he has concentrated the calculations and findings of this paper on a second stage.

Such a system, using a liquid or molten metal, which would cover both a first and second stage of reheat is shown diagrammatically in Fig. 5, which is self-explanatory. Unfortunately, there is no known liquid which would remain undecomposed or not become vaporised at the temperatures of 1,000 deg. F. and over which are required. It is necessary therefore to employ a molten metal and here again choice is limited since it must be fluid under all conditions. This development, however, is already being pursued as reported at the recent Atomic Power Conference and referred to by Dr. T. F. Brown in his Thomas Lowe Gray lecture.[6]

The circulation of a gas under high pressure

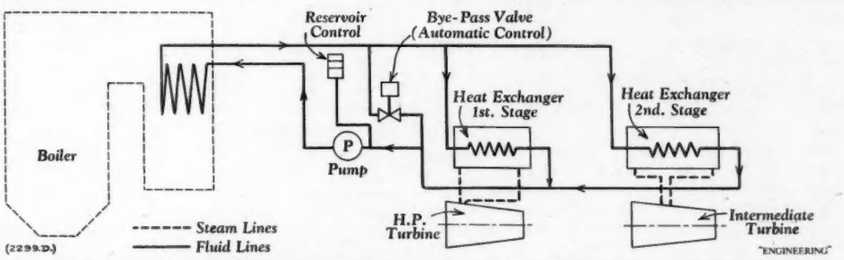

Fig. 5 The practical application of two-stage reheat requires a heat-transfer system employing a circulating secondary fluid such as molten metal.

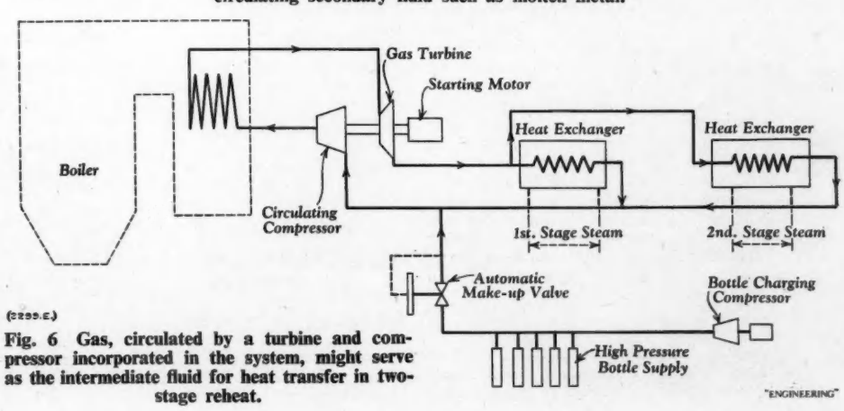

Fig. 6 Gas, circulated by a turbine and compressor incorporated in the system, might serve as the intermediate fluid for heat transfer in two-stage reheat.

would seem a quite feasible solution, especially if only a small heat drop in a gas turbine were necessary to drive the circulating compressor. The power required would represent only the circulating-pressure drop, which should not exceed 5 per cent. of the total pressure. Thus, if air at 2,000 lb. per square inch were used, a single-stage axial fan of 1·05 to 1 pressure ratio would suffice. The equivalent temperature drop in the turbine would be only 13 deg. F. if allowance is made for losses in the turbine and the axial fan; but the advantage of lower-temperature air arriving at the fan suction should be taken into account. A system of this nature[9] is shown diagrammatically in Fig. 6.

ANALYSIS OF A MODERN POWER PLANT

It is now fairly well established that some of the early calculations of heat-rate gains are too high, when allowance is made for pressure drops, leaving loss, and higher steam temperatures. For instance, Harris and White's figures[6] give a maximum of 6·1 per cent. gain for 2,000 lb. per square inch and 1,000 deg. F. at 1½ in. of mercury condenser pressure where previous calculations would have been extrapolated to about 10 per cent. for these conditions. These authors estimate a gain of 6·7 per cent. when the condenser pressure is 1 in. of mercury. This point stresses the increasing importance of a good vacuum.

The author decided to take a typical high-pressure modern reheat unit for which the leading design details are given and examine the results of superimposing a second stage of reheat. The plant chosen is the Philip Sporn 150-MW unit[2] previously mentioned.

The boiler efficiency of this unit is 90 per cent. and the net heat rate is 9,270 B.Th.U., which is better by 5 per cent. than that with single expansion and entails only a 2 per cent. greater capital cost. A maximum constant steam rate of 935,000 lb. per hour at 2,015 lb. per square inch absolute is available, with a temperature of 1,050 deg. F. at the superheater outlet. It is returned at 652 deg. F. and 435 lb. per square inch to the reheater for reheat to 1,000 deg. F. The reheated quantity is 844,670 lb. per hour and it is delivered to an intermediate turbine, which exhausts at 8 lb. per square inch absolute to a double-flow low-pressure turbine with a condenser pressure of 1½ in. of mercury. Six stages of regenerative feed heat are provided to give a feed-water temperature to the economiser of 441 deg. F.

COMPARISON OF CYCLE EFFICIENCIES

It is essential to obtain a reasonably accurate value for the true cycle efficiency which these figures represent since the heat-rate gain will be over-estimated if the original cycle efficiency is taken at too low a figure. The overall efficiency indicated by a heat rate of 9,270 B.Th.U. is 37·1 per cent., and if this is corrected for a boiler efficiency of 90 per cent., it becomes 41·3 per cent. A further adjustment for generator efficiency and electrical losses at 95 per cent. raises the cycle efficiency to 43·4 per cent. The leaving loss is important since it must be applied to both the original and reheated conditions. If, as will be done in these calculations, the heat-drop figures are all taken with respect to condenser vacuum without leaving loss, the original cycle must be assumed for comparison to operate likewise in this ideal manner. Thus, with a leaving loss of 4½ per cent. of the total heat drop, the comparison efficiency must be increased from 43·4 per cent. to 45·35 per cent.

A check calculation from steam stop-valve conditions with allowance made for feed-heat tappings gives a comparatively close nominal efficiency of 46 per cent., that is without leaving loss. This latter figure, rather than the former, has been adopted in order to avoid exaggeration of the effect due to second-stage reheat.

CALCULATIONS FOR SECOND STAGE

The starting point for the calculations may be regarded as that at which the steam leaves the first reheat at 415 lb. per square inch absolute and 1,000 deg. F. Steam at pressures of 50, 70, 88 and 110 lb. per square inch absolute and a temperature of 1,000 deg. F. was taken for the second-stage reheat and, at 50 lb. per square inch absolute, three temperatures were selected at random points of 764 deg. F., 900 deg. F. and 1,000 deg. F. The results shown in the accompanying table were obtained.

These values are plotted in Fig. 4, on a percentage heat-drop base (from 415 lb. per square inch absolute to condenser pressure) and a curve is included to give the calculated average turbine reheat factors for this range. It is significant that the maximum reheat gain coincides with the maximum turbine reheat factor. As J. K. Salisbury[4] points out, the turbine reheat factor is a function of "geometry" of the "Mollier" diagram, but it is in fact the "geometry" of the pressure/total heat diagram used in this paper which governs the overall reheat results.

ADVANTAGE OF SECOND STAGE

There is one important deduction from these tabulated results and Fig. 4; it is that reheat gain on a second stage for this unit has a rather sharp maximum at about 40 per cent. of the second heat drop rather than at about 30 per cent. or less of the total drop for a single stage. The order of magnitude is just about half that obtained on the single stage, but is, of course, additive as calculated.

It is significant to note that Philip Sporn himself accepts only a 5 per cent. gain against the 6·1 per cent. quoted previously as Harris and White's calculated figure for these conditions. An additional 2·85 per cent. gain in heat rate from a second stage, as calculated here, would give the Sporn 150-MW plant the very enviable heat rate of 8,964 B.Th.U. per kilowatt-hour generated.

TABLE I.—*Heat-rate gains for second-stage reheat, calculated in terms of initial pressures for a theoretical second stage superimposed on an existing plant. Values plotted in Fig. 4*

Pressure (lb. per square inch absolute)	Percentage heat-rate gain		
	764 deg. F.	900 deg. F.	1,000 deg. F.
50	0·45	1·3	1·97
70	—	—	2·85
88	—	—	2·70
110	—	—	2·54

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[2] Philip Sporn, "The 2,000 psi, 1,050 F and 1,000 F Reheat Cycle at the Philip Sporn and Twin Branch Steam-Electric Stations." *Trans. A.S.M.E.*, vol. 70, page 287 (1948).

[3] Philip Sporn and S. N. Fisher, "The Development and Implementation of a Generation Program on the American Gas and Electric Company System." *Trans. A.S.M.E.*, vol. 74, page 613 (1952).

[4] J. K. Salisbury, *Steam Turbines and Their Cycles.* John Wiley and Son, Inc. (1950).

[5] W. E. Blowney and G. B. Warren, "The Increase in Thermal Efficiency due to Resuperheating." *Mechanical Engineering*, vol. 47, page 455 (1925).

[6] E. E. Harris and A. O. White, "Development in Resuperheating in Steam Power Plants." *Trans. A.S.M.E.*, vol. 71, page 685 (1949).

[7] R. L. Reynolds, "Reheating in Steam Turbines," *Trans. A.S.M.E.*, vol. 71, page 70 (1949).

[8] T. W. F. Brown, "High-Temperature Turbine Machinery for Marine Propulsion," *Proc. I. Mech. E.* (Thomas Lowe Gray Lecture, 1954).

[9] Applications for Patent, Alorix Limited, 32 St. James's-street, London, S.W.1, and I. Lubbock. No. 6,333, March 3, 1954, and No. 10,329, April 8, 1954.

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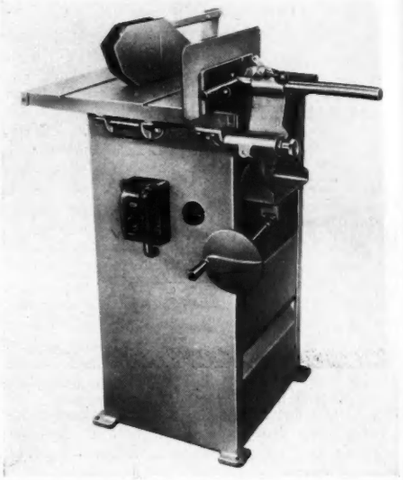
SPRING BALANCES CALIBRATED IN NEWTONS: ERRATUM

On page 81 of our issue of July 16 we stated that the divisions on the scales of the two Salter spring balances were 0·10 lb. and ¼ lb., respectively. This should have read 0·10 Newton and ¼ Newton.



Sawbench fitted with a 10-in. diameter blade which can be replaced by a wobble saw of ½-in. capacity, a 10-in. sanding disc and other special blades.

3⅛-IN. CAPACITY SAWBENCH

Saw Adjusted Manually

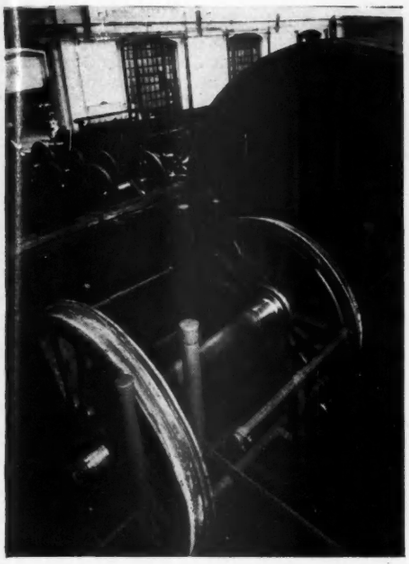
A sawbench for cutting timber up to 3⅛ in. thick has been added to the range of machines of this type being made by the Startrite Engineering Company, Limited, Waterside Works, Gads Hill, Gillingham, Kent. It is designed for a wide variety of operations in addition to straight, cross and bevel sawing. The saw is shown in the accompanying illustration and is known as the "Startrite 10."

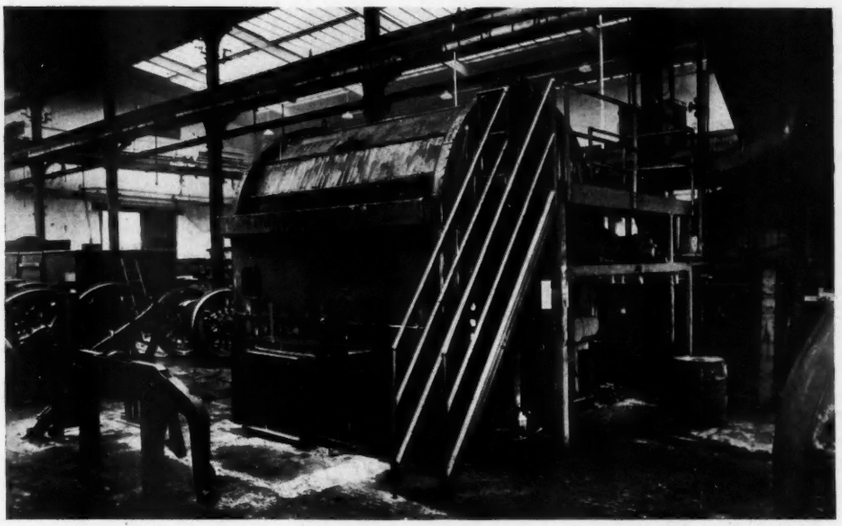
A guide and protecting fixture can be bolted to the table for grooving and shaping. Included with it are adjustable vertical and horizontal guide pieces mounted on semi-elliptical spring-steel pressure plates. The guides give support to the timber as close as possible to the moulding cutter and ensure complete protection of the operator.

A moulding with a safety fixing for knives is made and this is available as extra equipment. There are also sets of two interchangeable knives in nine different patterns for rebating, chamfering, fluting and joint moulding. Besides these, a wobble saw of ½ in. capacity, a 10-in. diameter sanding disc and special blades for cutting metals and plastics may be fitted.

The saw table is made of cast iron and measures 20 in. by 30 in. with mitre grooves either side of the blade, as shown in the illustration. The saw spindle is mounted in ball bearings protected by dust seals. A handwheel and screw controls the rise and fall of the 10-in. diameter saw for setting the depth of cut. A canting fence accommodates work up to 14 in. to the right of the saw blade. To accommodate large pieces of timber a trunnion bracket can be lowered to allow the fence plate to be operated in the extended position. For accurate setting of the fence, a subsidiary fine-screw adjustment has also been incorporated.

The blade is enclosed on both sides by a guard and this offers protection at any depth of cut. Both the arbor mechanism and fence are fitted to the under side of the table and the complete unit is mounted on a cabinet fabricated from heavy-gauge steel and welded together. The power for driving the saw is taken from a ¾-h.p. electric motor and transmitted to the arbor by a three-belt drive. To suit certain classes of work motors of higher power are occasionally fitted.





A machine for cleaning locomotive wheel sets, installed at the Derby Works of British Railways. A hot solution of caustic soda is sprayed on the wheels while they are rotated.

CLEANING MACHINE FOR LOCOMOTIVE WHEELS

Using Hot Detergents

British Railways (London Midland Region) have installed at their Derby works a machine capable of cleaning locomotive wheels up to 7 ft. 3 in. diameter on the tread. It consists of a chamber in which the wheels, having been lowered in by a crane, are slowly rotated and sprayed with a detergent. The machine is shown above.

The wheels rest on rollers which are pivoted to enable all sizes to be accommodated. One roller in contact with each wheel is driven through gearing from an electric motor. The chamber is enclosed at the top by steel shutter doors operated by an electric motor, which automatically stops as the doors reach the limit of their travel in either the open or closed position. Spray pipes are arranged in the chamber so that jets under pressure are projected on to all parts of the wheels, axles, crank sweeps and spur gears where these are fitted to Diesel-locomotive wheel sets. Two centrifugal pumps at the base of the machine, electrically interlocked with the door mechanism supply the detergent at a pressure of 25 lb. per square inch. After the pumps have been working for ten minutes, the wheel set is thoroughly cleaned, and within a minute or so of the doors being opened the wheels are in a dry condition ready for lifting from the machine.

A solution of caustic soda in water (2 to 3 per cent. by weight) is used as the cleaning agent, although experiments are being carried out with other detergents. The temperature is raised to 180 deg. F. by steam coils fitted to the tank. Arrangements are provided for draining the solution from the machine and doors are provided for the removal of the sludge.

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MOBILE COAL-HANDLING PLANT

Screening, Bagging and Weighing at 24 tons per hour

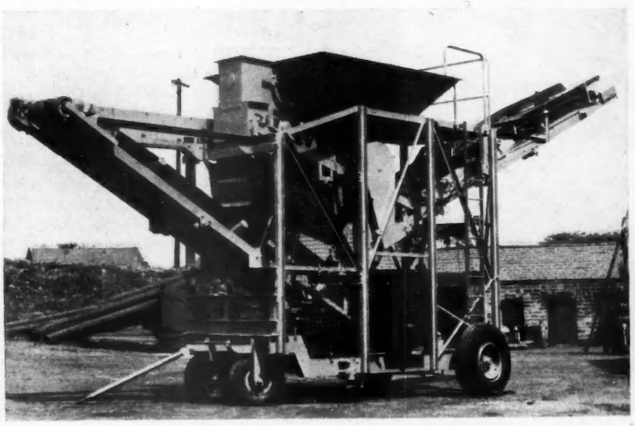
A mobile coal screening, bagging and weighing plant has been developed by Crone and Taylor (Engineering), Limited, Sutton Oak, St. Helens, Lancashire. It consists of two mobile units, one for screening, the other for bagging and weighing.

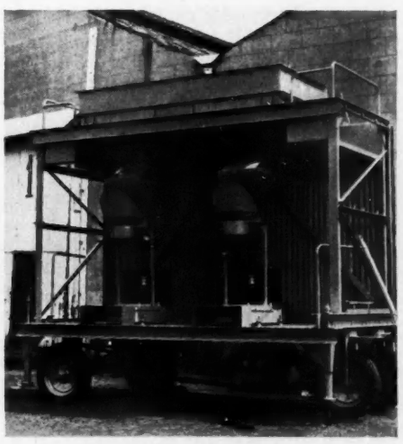
The screening unit, shown below, which can handle 35 tons of coal per hour, removes all coal of less than 1 in. It consists of a hopper, a feed conveyor fitted under the hopper to give an even flow to the screen, a single-deck mechanically-vibrated screen, a conveyor that removes the fines to tip lorry, and the main 24-in. belt conveyor which brings the cleaned product from the screen to the bagging and weighing unit. This conveyor is hinged to permit its being raised to the necessary elevation for delivering into the hoppers of the bagging unit, or lowered for filling lorries or rail trucks. It is equipped with a hand-operated hydraulic control.

Since the bagging unit cannot handle lumps of a size greater than 8 in., the receiving hopper of the screening unit is fitted with a strong 8-in. grid, and oversize pieces are broken by an operator who also controls the plant. The drive is by Diesel engine or electric motor. The screening unit's capacity, when handling coke and removing breeze below ½ in. in size, is 15 tons per hour.

The bagging and weighing unit which is shown below is equipped with two hoppers which are fed from a central position by the main conveyor of the screening unit. Radial outlet dampers give the necessary control of the flow of coal into the bags. Avery dial-type weighing machines, which give dial readings from 15 lb. below the set value up to 5 lb. above it, are fitted as standard. Levelling screws enable the unit to operate on a level base when on uneven ground. The back and two sides are covered with galvanised sheeting to protect the operators and to reduce flying dust. If the bagging and weighing unit are employed without the screening unit, it is necessary to fit 8-in. square grids to both hoppers to intercept all oversize pieces. These pieces are broken, as in the case of the screening unit, by operators standing on conveniently-situated platforms.

The capacity of the unit depends upon the size of the coal and the percentage of fines, but when dealing with 8-in. coal containing up to 25 per cent. of fines, 24 tons per hour for the unit is the average output. Both units are fitted with pneumatic tyres and tow bars, and can be moved quickly from one coal stack to another.





On the left is the screening unit, and the clean coal is raised by the rear conveyor to be fed into the hoppers of the bagging and weighing unit which is shown on the right.

MECHANICAL POTATO HARVESTER

4½ TONS OF SOIL LIFTED PER MINUTE

One of the most difficult of the problems that have faced agricultural engineers is harvesting root crops, among them the potato, and the need for a potato harvester has been accentuated by the difficulties involved in lifting this crop by hand, and the fact that labour is becoming increasingly costly and difficult to obtain. Among the many who have concentrated on the design and development of such a machine is Mr. P. J. Packman, whose efforts resulted in a harvester which won the R.A.S.E. Silver Medal at York, in 1948, and a prize award at the International Harvester Trials, 1952. On page 391, vol. 170 (1950), we illustrated an earlier model of the Packman potato harvester. Shown below is the latest machine, which has taken 14 years to develop. It is now considered to have reached a satisfactory stage of development and is being produced by Thos. Storey (Engineers), Limited, Agricultural Division, Vernon Works, Stockport.

It is essential that such a machine must travel along a straight path and cannot lift potatoes which have been planted in uneven rows and at various depths without damaging the tubers or missing part of the crop. The designer therefore recommends that his harvester is used in conjunction with his mechanical potato planter, also being made by Thos. Storey, Limited. This ensures that the seed potatoes are sown in a straight row, precisely spaced and at a constant depth. A description of this machine was given in ENGINEERING, vol. 170, page 90 (1950). Briefly, the planter consists of a number of rotors comprising a series of arms disposed radially about an axle with a small cup at the end of each arm. The potatoes are fed one to a cup from chitting trays and as the machine passes over the ground the arms rotate like a wheel and each cup places a seed potato on the surface of the ground.

Among the problems that face designers of potato-harvesting machines is the fact that a machine of this nature has to lift up to 20 tons of potatoes per acre at an economical rate and deliver them clean and undamaged to a trailer or sacks. Furthermore, the conditions under which this has to be done vary considerably, and the substance to be removed includes different types of soil, stones, clods, haulm (the leaf and stalk) and weeds, apart from the fact that the potatoes to be lifted and sorted vary in size considerably. When running at 2 m.p.h., therefore the machine has to eliminate something like 4½ tons of soil per minute, and on a heavy crop about 1,800 potatoes pass through the machine every minute.

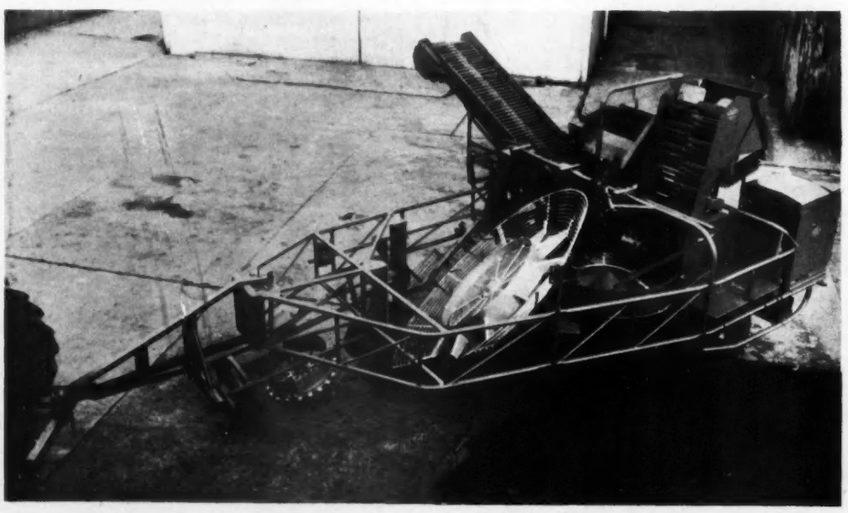
LIFTING AND SORTING

When harvesting, the crop is attacked first by a haulm stripper rotated by a series of shafts and belt drives, extending forward from the rear of the machine. This is followed by a plough-share that lifts the potatoes and surrounding soil and passes them to the large saucer-shaped riddle which earries them, as it rotates, to a second riddle of small diameter. This riddle disposes of most of the remaining soil. The larger riddle is continually being cleaned by a rubber brush placed behind it and another brush of a similar nature gently deflects the potatoes and stones from the second riddle into rubber buckets on the elevator.

A platform is built alongside the elevator on which a labourer stands while picking off any rubbish mixed with the crop. From the elevator the potatoes are tipped on to a belt-type conveyor covered by spike-shaped rubber fingers, giving it a brush-like surface. The weight of the stones and clods of soil that remain sink in between the spikes on this surface and are carried along with pieces of grass and other weeds to be discharged on to the worked land, while the potatoes, being of less weight and often larger, rest on top eventually to bounce off the side of the belt, which is set at an angle, on to a rubber receiver and are carried by a second elevator to a trailer towed alongside.

A platform at the rear machine also enables a labourer to stand alongside the conveyor-belt to throw back any potato that may have strayed. Another person can, if necessary, stand alongside the final elevator to remove any remaining rubbish.

The machine is driven by a Ford-10 engine. The frame is constructed from steel, and divided among the many pieces of rotating machine are about 50 ball races. The dusty nature of the work also meant that additional precautions had to be taken to keep the engine and bearings free from dirt and grit. Much of the recent development work on these machines has been carried out in conjunction with the National Research Development Corporation, the offices of which are at 1 Tilney-street, London, W.1.



Up to 1,800 potatoes can be raised and sorted every minute by this mechanical harvester which is designed to travel behind a tractor at about 2 m.p.h.

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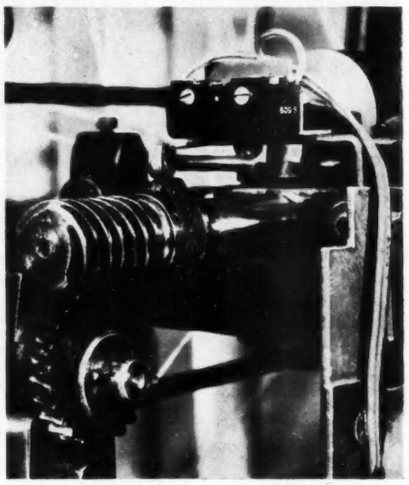


ELECTRIC RECORDER FOR CHECKING MACHINE-RUNNING TIMES

For recording the running and idling times of small or high-speed machines on which it is impracticable to fit a standard pendulum-type recorder, a new electrically-operated recorder has been devised by Servis Recorders Limited, 19 London-road, Gloucester. In this instrument, the stylus, which records on a 6-in. circular chart, is actuated electro-magnetically by impulses from a small battery or from a mains-supply through a low-voltage transformer. The recorder can, therefore, be installed remotely from the plant under observation, or it can be supplied as a portable instrument.

Any simple make-and-break mechanism, operated by a rotating shaft or other moving part of the machine at speeds up to about 700 r.p.m., serves to actuate the stylus, which produces a thick line on the chart when the machine is running. When the machine, and the stylus, are stationary, the chart shows a thin line. In the example illustrated, a cam on a rotating shaft is used to operate a micro-switch.

★ ★ ★

ELECTRICITY IN HORTICULTURE

Heating, Lighting and Sterilising

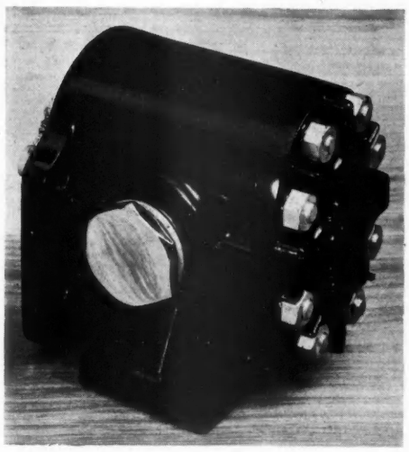
Some of the less widely known uses of electricity were shown recently at the Stockport flower show in an exhibit staged jointly by the Merseyside and North Wales Electricity Board, the North Western Electricity Board and the British Electrical Development Association. Part of the exhibit was a complete tomato-propagating house illustrating the value of bench warming, light irradiation and space heating, as obtained from electricity. Automatic control of both temperature and irradiation was installed.

The use of electrical soil warming and frost-protection equipment was demonstrated in a commercial frame. The frost-protection equipment, consisting of copper-sheathed cables around the walls of the frame, has proved quite suitable for protecting dahlia and chrysanthemum cuttings during the hardening-off period. An electrical soil steriliser which will heat 5 cwt. of soil to 180 deg. F. in 1½ hours was also exhibited at the show.

HIGH-PRESSURE HYDRAULIC GEAR PUMP

A new range of high-pressure hydraulic gear-type pumps particularly suitable for agricultural machinery, earth-moving equipment, mechanical handling gear and other mobile applications where a compact, lightweight hydraulic installation offers advantages, has been developed during the last eighteen months. The designers, Dowty Hydraulic Units Limited, Ashchurch, Gloucestershire, who have recently commenced production of the new units at their Coventry works, claim that there is no pump of competitive cost in the United Kingdom capable of the performance of this industrial hydraulic pump, which can generate pressures up to 2,000 lb. per square inch. The pump will be produced in 14 capacities ranging from 1 gallon to 50 gallons per minute at 1,500 r.p.m. A typical unit is shown in the accompanying illustrations.

The ability of the Dowty pump to operate at such high pressures results from a pressure-balancing system which effectively prevents leakage past the faces of the gears. This feature has, moreover, been attained without sacrificing simplicity of manufacture, as will be apparent from the illustrations, although high precision operations are called for to provide the necessary close tolerances.



The Dowty high-pressure pump is to be produced in 14 capacities ranging from 1 to 50 gallons per minute at 1,500 r.p.m., at pressures up to 2,000 lb. per square inch.

The pump is designed for rapid production by high-precision machine tools. The high pressures obtainable result from a pressure-balancing system which prevents back-leakage of oil. The pump provides its own forced-lubrication feed to the main bearings.

As shown in the lower illustration, the gear shafts are carried in plain bushes, the outer ends of which are grooved and fitted with synthetic rubber O-rings manufactured by Dowty Seals, Limited. Oil from the pump outlet fed between the circumference of the bush and the pump body enters the recess between the end cover and the O-rings, building up a balancing pressure on the end of the bushes, thus preventing fluid from leaking back past the gears.

The pump provides its own forced-lubrication feed to the main bearings. Oil trapped between the gear teeth as they mesh is forced through the bearings and returns by way of the hollow shaft and by passages in the pump body, through a spring-loaded pressure-maintaining valve set at about 6 lb. per square inch. Leakage past the drive shaft is prevented by a synthetic-rubber rotary oil seal.

The assembly of the pump is simple and suitable for rapid production; the mechanism is housed, in two parallel intersecting bores formed on a precision-boring machine, in a light-alloy die-cast body enclosed by end covers. The gears, of case-hardened steel, are machine-cut, the tips and sides of the teeth being ground to fine limits. The plain cylindrical bushes, of lead bronze, are also precision finished. There are four basic pump sizes for each of which standard tooling and end plates are employed, but in which the width of the gears and bushes can be selected from three or four sizes to provide the desired delivery.

Tests are stated to have shown that the pump retains its high performance over a long period. Pumps which have completed 3,000 hours under severe overload conditions show a negligible change in performance, and will, with normal usage, have a life exceeding that of the associated equipment.

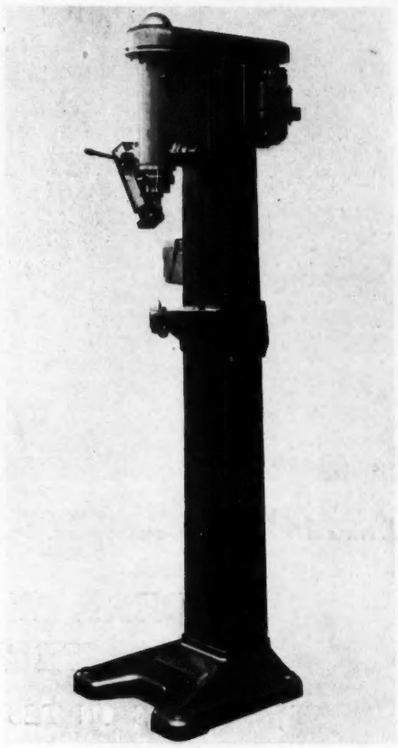
With the present trend towards the increasing use of high-pressure hydraulic power for operating agricultural machinery, the Dowty company expect to find a wide demand for the new pump in this field. Their first large order, in fact, is for supplying pumps for agricultural tractors in Canada; this contract has been secured in competition against American manufacturers.

* * *

MACHINE FOR LAPPING CENTRE HOLES

The pillar-mounted machine shown on this page, recently introduced by A. A. Jones and Shipman, Limited, Narborough-road South, Leicester, has been designed for lapping centres, drilled in the ends of shafts and other pieces, which have suffered slight distortion at the time of cutting or by subsequent hardening. The machine consists of a high-speed motor-driven spindle carrying the 1-in. diameter lapping cone, a diamond truing device for forming the cone wheel to the correct angle, and a tailstock the position of which can be adjusted to suit varying lengths of work up to 40 in. The distance from the spindle centre to the face of the column is 6½ in. The machine will lap holes up to $\frac{1}{16}$ in. in diameter, and the spindle speed is 1,140 r.p.m.

The spindle is mounted on ball bearings carried in a quill which allows a vertical feed of 2 in., controlled manually by a feed lever. A spring of large diameter encircling the upper portion of the quill ensures balance and a sensitive feed. The drive to the spindle is from a motor mounted at the rear of the machine and is transmitted through a belt and pulleys. The motor bracket is adjustable for the purpose of maintaining the correct belt tension, and the spindle-driving pulley is mounted on independent ball bearings to ensure that belt tension does not in any way affect alignment of the spindle. The belt and pulleys are guarded by a removable cover.



This pillar-mounted machine has been developed for lapping the centre holes in the ends of shafts and other parts to ensure perfect alignment when the workpiece is mounted between centres in a lathe or other machine.

The head carrying the spindle and feed mechanism is secured to the upper portion of the machine column and is aligned by a key engaging in the central slot of the column which, as can be seen, is of box section and is mounted on a substantial base. The tailstock is arranged for vertical adjustment and is quickly and easily clamped in position by movement of a small handle. It is located by means of a key engaging a slot in the centre of the machine column. The centre, which is made from cast steel and hardened, has a standard morse-taper shank.

The diamond truing device is attached to the spindle head and is operated by a conveniently-placed lever. The diamond is mounted on the end of a long sleeve to ensure accurate travel at an angle of 30 deg. to the vertical plane. When required for dressing the lapping cone, it is only necessary to manipulate the control lever which traverses the diamond across the lap at the correct angle. To control the amount of dressing a truing feed screw carried in a clip on the spindle quill is provided, adjustment of this screw advances the spindle in the vertical plane and regulates the amount removed from the lap by the truing diamond.

The motors of the standard machines are arranged for operating on 220/250-volt or 380/440-volt, 3-phase 50-cycle alternating current. The floor space normally occupied by this machine is 18½ in. by 26½ in. and the overall height is 74 in. The net weight is about 4 cwt.

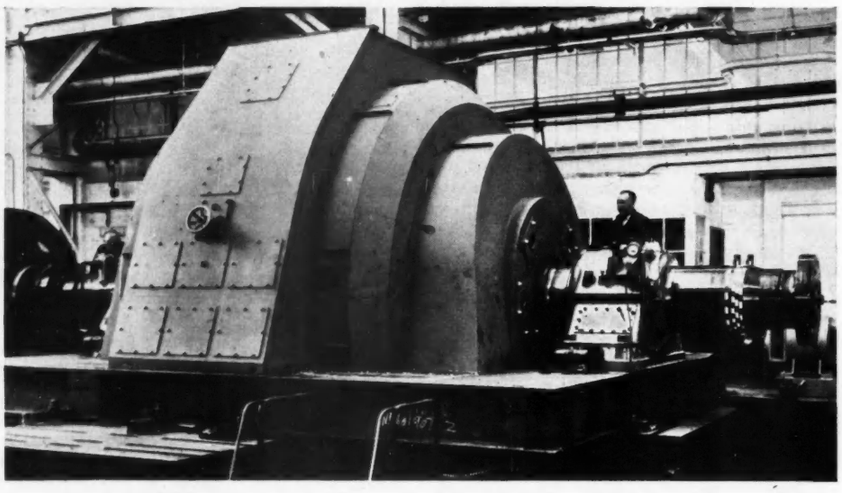


Fig. 1 35,294-kVA 375-r.p.m. horizontal water-wheel alternator for the Finlarig power station of the North of Scotland Hydro-electric Board, shown on test in the Rugby works of the British Thomson-Houston Company, Limited.

MODERN WATER-WHEEL ALTERNATORS

TWO TYPES ON TEST AT RUGBY WORKS

We recently had the opportunity of seeing two large water-wheel alternators of different design on the test bed at the Rugby factory of the British Thomson-Houston Company, Limited. The occasion was unusual since, while it was formerly the practice to assemble and test all machinery at the makers' works, it is now more common, in order to save time, not to erect them until they finally reach their working location. In addition, the conditions under which these machines will work has necessitated some differences in their construction which it is of interest to describe.

One of these machines is to be installed in the Finlarig station of the North of Scotland Hydro-Electric Board. This station is being built near Killin at the western end of Loch Tay and will be one of five forming the Ben Lawers scheme. It will be supplied with water from Lochan-na-Lairige, which lies 1,620 ft. above the sea and the level of which is being raised 90 ft. by building a dam 1,250 ft. long and 130 ft. high across its southern end. The head waters of streams in the neighbourhood are being diverted into this reservoir through aqueducts, thus increasing the effective catchment area. The loch will be connected by a tunnel two miles long to the surge shaft and valve house and thence through a high-pressure steel pipe-line to the power house.

HIGH-HEAD TURBINE

The turbine, which is being built in Scotland to the designs of Boving and Company, Limited, 56 Kingsway, London, W.C.2, will operate under a gross head of 1,348 ft., which is so far the highest head utilised in any of the Board's projects. It is of the twin-jet double-overhung Pelton type, there being two runners located one at each end of the alternator shaft. Each of these runners weighs about 5 tons and consists of a forged steel disc to which 18 buckets of cast stainless steel are bolted. The jets, of which there are two for each runner, are controlled by needle valves. When fully opened these valves allow a stream of water 7½ in. in diameter and travelling at 190 m.p.h. to issue from the nozzle and impinge upon the buckets. A load of 20 tons is thus imposed on each bucket twice in every revolution. The output of the machine is 42,000 h.p. at a speed of 375 r.p.m. when operating under a head of 1,250 ft. and the water consumption is almost 10 tons per second.

ALTERNATOR CONSTRUCTION

The alternator, illustrated in Fig. 1, has a maximum continuous rating of 35,294 kVA and generates three-phase current at 11 kV and 50 cycles with a lagging power factor of 0·85. It has been designed to withstand, with ample margin, the stresses which occur when it is rotating at the runaway speed of the turbine, in this case 705 r.p.m.

The stator frame is of fabricated construction and, to comply with transport limitations, is in two parts, being split on the horizontal diameter. Dovetail key bars, which are welded inside the frame, support the stator core which consists of segmental steel laminations insulated on both sides. The core is clamped between steel segmental flanges which prevent any movement or vibration. The winding is carried in slots in the core and is of the double-layer Roebel bar type, the transposed conductors reducing the losses in the winding to a minimum. The main insulation on the slot portion of the bar is micafolium and, on the end windings, mica tape reinforced mechanically with glass tape. The whole stator when fully wound weighs 58 tons. Fig. 2 shows the wound stator nearing completion.

The rotor comprises a shaft, almost 30 ft. long, on which are shrunk and keyed a number of thick steel plates. Dovetail slots are machined in the rotor body to carry the poles. Taper keys are driven in from both ends to pull the poles hard down on to the rotor body. The field coils are fabricated from copper strip, the main insulation being micanite and the inter-turn insulation asbestos. There is a heavy damping winding, consisting of copper bars embedded in the pole faces. The complete rotor weighs 127 tons and, as this is too heavy to be transported to site, all sixteen poles and four of the rotor plates will have to be removed to bring the weight down to the permissible 77 tons.

The bearings are of the Michell type and are supplied with cool filtered oil from an external lubricating system. The ventilation is of the closed-circuit pattern, hot air being discharged from the bottom of the stator through two air/water heat-exchangers in the machine pit. The cooled air is then forced into the alternator at each end by aerofoil fans on the rotor.

EXCITER ARRANGEMENTS

An interesting constructional feature is that the main exciter is located between the stator and the main bearing at the end opposite the slip-rings, its armature being carried on the main shaft. This reduces the overall length of the set. The pilot exciter and governor generator are mounted on a common baseplate and are flexibly coupled to one Pelton runner. The governor generator provides a three-phase, 50-cycle supply for the governor pendulum motor. Any change in speed of the set is thus relayed to the governor, which initiates the necessary correction to the settings of the turbine needle valves and thus restores the speed to normal.

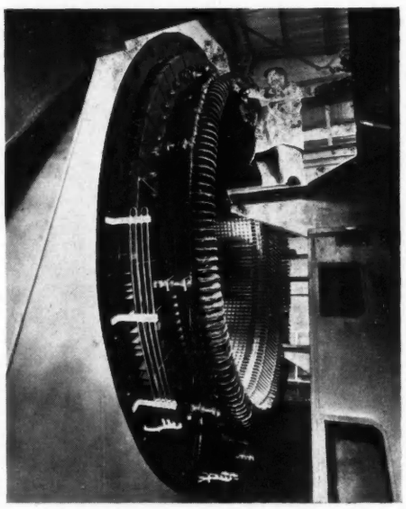


Fig. 2 Stator of the water-wheel alternator for Finlarig power station.

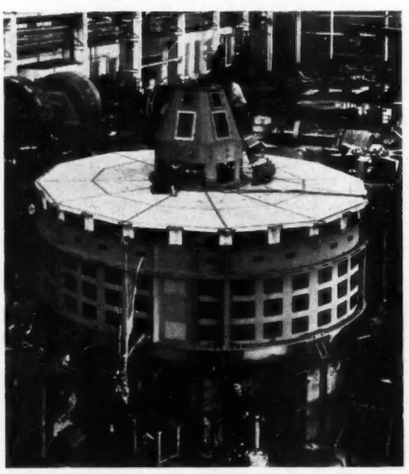


Fig. 3 One of the four 44,444-kVA 136-r.p.m. vertical water-wheel alternators for Roxburgh power station, New Zealand.

Fig. 4 Stator frame of the Roxburgh alternator undergoing ring-flux tests at the works.

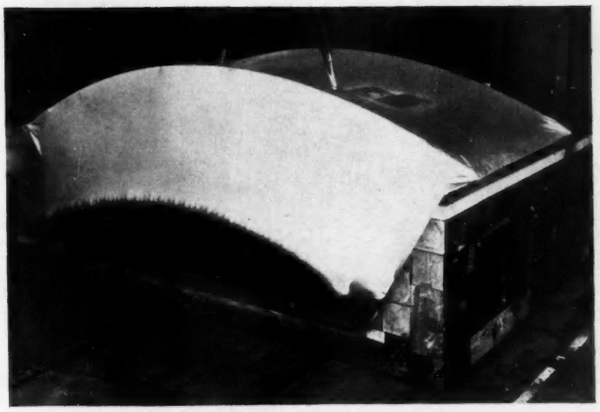


Fig. 5 Stator frame of Roxburgh alternator cocooned ready for shipment. The slings sealed into the cocooning are for handling during shipment.

The control equipment, which is also of British Thomson-Houston construction, will enable the set to be started up automatically, by pressing a button either in the power station itself or in the remote control centre at Killin. It will thus be possible to synchronise the machine remotely and to adjust the load and voltage as may be necessary. Alarm indications will be relayed back to the control centre, while more serious faults will automatically shut down the machine.

44,444-KVA ALTERNATORS

The machine for New Zealand is one of four which are being manufactured by the British Thomson-Houston Company for a power station of the State Hydro-Electric Department, on the River Clutha (the largest in New Zealand), near the town of Roxburgh in Central Otago. When complete, this station, which is situated 100 miles inland from Dunedin, will have an installed capacity of 320 MW, or nearly half the present installed capacity of the Dominion. It will be supplied with water from a lake about 18 miles long the level of which is being raised 150 ft. by a gravity dam of mass concrete. The power station will extend part of the way across the river at the base of this dam and will eventually contain eight 44,444-kVA sets.

Each of the four sets, which are now being supplied, include a Francis turbine, manufactured by the Dominion Engineering Company, Montreal, and designed to operate at a speed of 136 r.p.m. under a gross head of about 148 ft.

To ensure that the alternators comply fully with the guarantees, the first machine, as shown in Fig. 3, has been fully assembled and completely tested at Rugby. The remaining machines will be checked for mechanical accuracy and subjected to such electrical tests as are practicable. The most important of these comprises a ring-flux test on the stator prior to winding, so as to check that the core losses are comparable with those measured on the assembled machine. This test is shown in progress in Fig. 4, which also gives a good idea of the size of the stator frame.

After test, such parts as are likely to be stored on site for some time prior to erection will be cocooned to avoid all possibility of deterioration. This includes such large parts as the stator sections shown in Fig. 5. To enable these heavy cocooned parts to be handled during shipping, slings are attached to them and brought out through the cocooning in such a way that they can be used without destroying the effectiveness of the air seal. A quantity of silica gel is placed inside the cocoon to keep the enclosed air dry, and a window enables its colour to be watched, thus providing a check that there is no leakage.

The alternators are 29 ft. in diameter and weigh 330 tons. When erected on site, only the exciters will be above the main floor of the station. Formed in the foundations are passages to give a closed circuit for the alternator cooling air through air/water heat exchangers. The exciters are self cooled.

ROTOR DESIGN

Being low-speed machines, the rotors, one of which is shown in Fig. 6, are of the laminated rim type. There are two forged flanges on the shaft to which heavy steel discs are bolted. Between these discs are eleven radial arms, which are slotted at their outer ends and form a spider. Round the spider is a laminated rim, which is built up from ¼-in. steel segments, the laminations being held firmly together by close-fitting bolts. The complete rim is held to the spider by taper keys in slots at the outer ends of the spider arms. The poles are keyed to dovetails in the outer periphery of the rim.

The pole bodies consist of steel laminations which have been consolidated under hydraulic pressure and held between heavy forged endpieces by rivets passing from end to end of the pole. The rotor field winding is fabricated from hard-drawn copper, the joints being of the jig-saw type. In each of the pole faces is a heavy damping winding, consisting of copper bars brazed at their ends to copper plates embedded in the pole body. This gives effective damping on the quadrature axis without the necessity for pole-to-pole connectors.

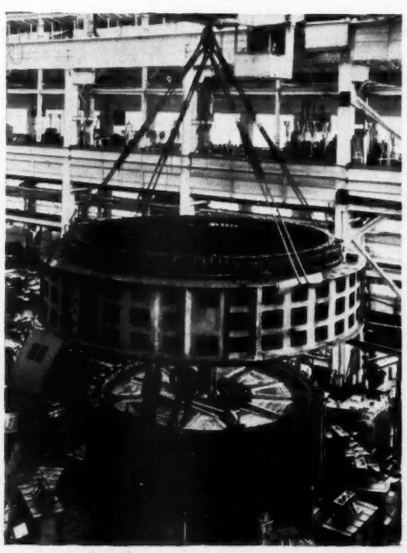


Fig. 6 The Roxburgh water-wheel alternator being assembled prior to shop tests.

THRUST BEARING AND BRAKES

The thrust bearing, which is mounted in the bottom bracket, is of the Michell segmental-pad type. It is designed to carry a load of 375 tons, comprising the weights of the alternator rotor and turbine runner plus the hydraulic thrust. Guide bearings, also of the Michell type, are mounted in both the bottom and top brackets. Brakes, which can also be used as jacks to lift the rotor off the thrust bearing are provided and operate against a ring of heavy polished steel segments which is mounted below the rotor rim. To avoid distortion due to the heat generated during braking, each of these segments is held loosely at the edges by clamps and is located and driven by a single dowel.

Solidly coupled to the top of the alternator shaft are the armatures of the main and pilot exciters and the permanent-magnet rotor of the governor generator. The latter provides a three-phase supply for the synchronous motor which drives the pendulum of the turbine governor.

* * *

PERMANENT TRADE DISPLAY OF MACHINE TOOLS

A display of contemporary machine tools to serve as a permanent exhibition is to be established in the showrooms of M. C. Layton, Limited, 96-98, Victoria-street, London, S.W.1. The showrooms, which were opened last month and are situated at Abbey Wharf, Mount Pleasant, Alperton, Wembley, Middlesex, comprise offices, reception rooms and a main showroom with a floor space of nearly 9,000 sq. ft. Accommodation is provided for well over 50 machines and a comprehensive assembly of most current models together with some second-hand equipment will be continually on view.

Speaking on the occasion of the opening, Mr. M. C. Layton said that the aim of his company was to save time for the production engineer, and to contribute towards this purpose the machine-tool display had been created. It had been planned so that within 30 seconds any form of machine tool could be shown in operation and, in addition, regular demonstrations were to be given one week each month. Visitors were at liberty to bring their own components and experts would be available to determine machining times and methods. Mr. Layton also called attention to a "Bargain Bench," on which were arranged various electric motors, chucks, craftsman's tools and small machines.

The motor-cruiser " Perpetua " has a Deborine Fibreglass hull 45 ft. long. The hull is proof against corrosion or insect attack, and is not expected to rot or warp.

FIBREGLASS MOULDINGS

SHIPS HULLS UP TO 100 FT. LONG MADE IN ONE PIECE

An example of the use of Fibreglass in nautical construction was shown to representatives of the technical Press on August 11, by a demonstration of the motor cruiser Perpetua.

This 45-ft. boat has the hull moulded in one piece from " Deborine," the grade of Fibreglass plastic used by Halmatic Limited, Rodney-road, Portsmouth. This firm have already made " Flying-15 " sailing craft and can now undertake hull mouldings of 100 ft. or more in length. The 45-ft. hull of the Perpetua is similar to the standard round-bilge Admiralty hull which is used for Admiral's barges, pinnaces and for police-boats. The superstructure was designed for Mr. de Laszlo, the managing director of Halmatics. A general view of the cruiser is shown in the illustration above.

COMPARATIVE STRENGTH OF 26 FT. HULLS OF THE SAME WEIGHT

—	Tensile strength, tons per sq. in.	Panel bend-break		Tup (impact)		Shear, lb. per sq. in.
		Lb. to break	Deflection at 300 lb.	Damaged, lb.	Pierced, lb.	
Wood ..	Across grain 3·3 / With grain, 0·47	.. 230-330	0·5 in.	32	48-64	5 500
Deborine ..	4·25-5·0	1,020-1,050	0·13 in.	64	72-80	15,000

A poly-ester resin mixed with a fire-resistant material is used to bind the glass fibres in Deborine. A small quantity of antimony-oxide has the effect of rendering the resin self-extinguishing so the material will not support a flame. In addition, it is not subject to attacks by the Teredo worm or by any other marine insect; neither will it, it is claimed, corrode or rot. No painting is needed, as the colouring can be mixed with the resin, and the laminate is therefore coloured right through. Deborine will, however, hold paint as well as wood does should any decorations be desired, but paint is not necessary and will not provide any additional protection.

During manufacture, Deborine shrinks very slightly, but no subsequent change occurs. Consequently, hulls can be made exactly to design with no danger of distortion or warping at a later date. Moreover, each hull from the same mould will be identical to the others, enabling mass-production to be used for fittings. It is claimed that glass-fibre hulls can be made far more quickly than wooden ones, once the mould has been made, a 26-ft. hull being completed in seven working days and a 45-ft. one in fifteen. The cost is about the same for a single hull, but is reduced if several are to be made from one mould. The chief saving is, of course, in maintenance and repairs. A damaged part can be cut clean out and a new piece bonded in; the work can be carried out on the spot and takes about one-tenth of the time required for wood. Being very resilient, Fibreglass materials do not easily dent under impact, and therefore quite a lot of minor damage is avoided. An economic advantage is that all the materials from which Deborine is made are home produced, so that manufacture is not dependent upon imports.

As regards strength, tests carried out on a 26-ft. hull showed that compared with a wooden one of the same weight, the Deborine was considerably stronger – and avoided the grain weakness of the wood. Some of these tests are listed in the table above. The result indicates that a Deborine hull of the same strength as a wooden one would be considerably lighter, and, being almost non-absorbent, it would not grow heavier with age. The hull of the Perpetua is strengthened by hollow ribs moulded into the shell; these can be seen in the second illustration, which also shows one of the Gardner engines. Previously, wooden frames were used.

Halmatic have now produced hulls for several different craft, the first being for a " Flying-20 " which was made as a duplicate of a wooden one; then a series of " Flying-15s " were made which have done a considerable amount of racing against wooden craft and have acquitted themselves well. A 26-ft. sea-going launch followed, and the 45-ft. Perpetua is the latest to be produced. Other craft are being planned, including a rowing eight.

The hull is strengthened by hollow ribs moulded integrally with it, as can be seen in this view of the engine compartment. Flexible mounting of the engines reduces vibration.

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THERMOPLASTIC PIPING

Easily Erected and Durable

The distribution of cold-water supplies, gases, compressed air and chemical products can now be made through a new light-weight non-metallic pipe called Marleythene, made by the Marley Tile Company, Limited, Lichfield-road, Branston, Burton-on-Trent, Staffs. The product, a thermoplastic tubing is available in the following diameters:—heavy gauge: ¼, ⅜, ½, ¾ and 1 in.; normal gauge: ½, ¾, 1, 1¼, 1½ and 2 in.

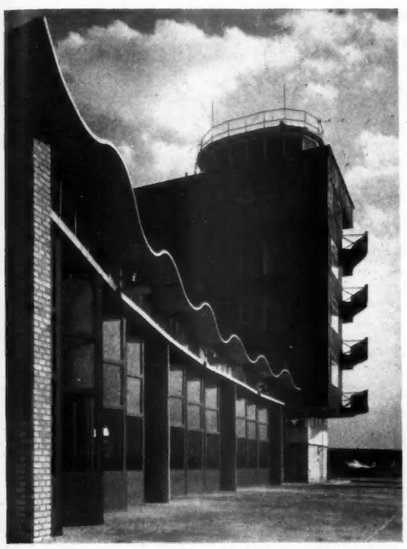
Marley theme has many advantages in the building, chemical, agricultural, dairy and food-manufacturing industries. It can be used for handling chemicals in liquid form, and in dairying it is ideal for milk and whey lines, being cheaper than the usual stainless-steel and copper alternatives.

The tube resists corrosion and erosion by most types of soil and water, and is unaffected by acids or alkalis, or contact with building material. Artificial manures, including sulphate of ammonia and superphosphate are said not to cause deterioration, and the freezing-up of water troughs and stand pipes will not damage the tube; resilience makes it immune to frost no matter how severely or how often the water it contains is frozen. Good thermal-insulation qualities prevent condensation forming so readily as on metallic pipe, and the material itself transmits far less noise and water hammer than metals. It is a non-conductor of electricity and so remains undamaged by stray electric currents. The tube does, however, soften with heat and although this simplifies jointing and manipulation, it is rendered unsuitable for use with hot water. Most of the jointing required can be made almost invisible and the tube is easily installed. It is claimed that the material has a long life without ageing.

CONTROL TOWER FOR HATFIELD AERODROME

A new control tower, shown in the accompanying illustrations, was put into operation at Hatfield aerodrome, the headquarters of the de Havilland Enterprise, towards the end of June. Most of the development flying for the de Havilland aircraft-engine and propeller companies is done from this aerodrome, which is located on Amber 2 Airway just inside the London Control Zone. The question of air-traffic control is therefore important.

The new control tower, which is furnished with the latest types of radio equipment, is situated 65 ft. above the ground at the south-west corner of a recently-built flight-test hangar, and gives an excellent view of the aerodrome and the surrounding country. Owing to the proximity of running aircraft engines, the problem of sound-proofing the control room was considerable. It has been overcome by adopting a heavy construction for the control room, which is set back from the main structure parapet, thus taking advantage of a certain amount of shielding; the walls and ceiling are lined with Celotex acoustic panelling. The windows, which do not open, are of Pilkington ¼-in. "Antisun" plate glass designed to dissipate 50 per cent. of the heat falling on them from the sun. The room is air-conditioned.



The new control tower block at Hatfield aerodrome is fitted with twin-channel direction-finding equipment, two sets of communication equipment and an instrument landing system.

The controllers' desk, from which two controllers normally operate independently, commands an excellent view of the aerodrome and surrounding country.

Normally, there are two controllers on duty in the control room to conduct radio communication with aircraft, as well as internal and external telephone calls. At peak periods both men may be fully occupied, and it is essential that each may deal with any of the lines of communication independently of the other and the communications equipment has been selected with this in view. Shown in the lower illustration is the controllers' desk and panel. The direction-finding indicator is located centrally in the panel with instrument-landing-system indicator lights immediately below it; on either side are the six very-high-frequency loudspeakers. To the right of the loudspeaker grilles are a barometer and an altimeter then, left to right, are situated wind speed and direction indicators and switches for runway and obstruction lighting. Frequency selector switches flank the internal telephone dial in the centre of the desk; radio-telephone and internal telephone hand sets are stowed on hooks just below the desk's edge.

The equipment includes a twin-channel remotely-controlled very-high-frequency direction finder (type A.D.200) supplied by Marconi's Wireless Telegraph Company, Limited Chelmsford. This set supersedes an earlier Marconi set which has given excellent service during the past 4½ years. The new site for the aerial is adjacent to the runway, thus directing pilots on to a straight run-in for landing.

Two sets of very-high-frequency communications equipment are installed. One of these sets was supplied by the Marconi company and comprises a twin-channel 50-watt transmitter (type TGV472A) and twin-channel receiver (type R.P.47C); and a low-power transmitter/receiver (type H16A.) The Marconi equipment operates on frequencies of 123·3, 122·5 and 131·3 megacycles per second. The other set, supplied by Pye Telecommunications, Limited, Cambridge, operates on frequencies of 123·3, 122·5 and 117·9 megacycles per second. It consists of a 50-watt transmitter/receiver (type PTC751) and two low-power transmitter/receivers (type PTC751).

An instrument landing system, also supplied by Pye Telecommunications, has been installed. Azimuth approach and glide-pattern transmitters, and an inner marker transmitter are situated at Hatfield. The outer marker transmitter is stationed at Panshanger, five miles north-east of Hatfield.

To allow for servicing without disturbing the controllers, the radio equipment is installed beneath the control room, lines being taken to the meters, loudspeakers and microphones in the control room. Also in the radio-equipment room is a Charleroi Electronique tape recorder made by Trevor-Johnstone Company, Limited, 14 Berkeley-square, London, W.1. It has been specially designed for airport use and is capable of running continuously for eight days.

LAUNCHES AND TRIAL TRIPS

H.M.S. "TORQUAY."—Anti-submarine frigate, built and engined by Harland and Wolff, Ltd., Belfast, for the Admiralty, London, S.W.1. Length, 370 ft. overall; beam, 41 ft. Armament comprises two 4·5-in. guns and two smaller guns. Propulsion provided by a high-powered geared steam turbine. Launch, July 1.

S.S. "HELCION."—Single-screw oil tanker, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for Shell Tankers, Ltd., London, E.C.3. Main dimensions: 530 ft. between perpendiculars by 69 ft. 3 in. by 39 ft.; deadweight capacity, about 18,000 tons on a draught of 29 ft. 7 in.; gross tonnage, about 12,000; oil-cargo capacity, 17,600 tons. Steam-turbo electric propelling machinery, developing 7,500 s.h.p. at 100 r.p.m. in service, and constructed by the British Thomson-Houston Co., Ltd., Rugby: two sets of impulse turbines direct-coupled to two-pole alternators, supplying three-phase current for an electric motor directly connected to the propeller shaft. Steam supplied by two Babcock and Wilcox forced-draught oil-burning boilers, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 14½ knots. Launch, July 2.

M.S. "SUSANNE SKOU."—Single-screw cargo vessel, with accommodation for ten passengers, built and engined by Burmeister and Wain, Ltd., Copenhagen, to the joint order of Ove Skou Ltd., and the Shipping Co. of 1937, Ltd., both of Copenhagen, Denmark. Main dimensions: 400 ft. between perpendiculars by 55 ft. 6 in. by 35 ft. 6 in. to upper deck; deadweight capacity, 6,950 tons on a draught of 24 ft. 4 in.; cargo capacity, about 430,000 cub. ft. (bales). Six-cylinder single-acting two-stroke Diesel engine, developing 7,500 b.h.p. at 115 r.p.m. Launch, July 7.

M.S. "TUGELA."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by the Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for Wilh. Wilhelmsen, Oslo, Norway. Main dimensions: 470 ft. between perpendiculars by 65 ft. by 43 ft. to shelter deck; deadweight capacity, 10,300 tons on a draught of 27 ft. 7 in. B. and W. eight-cylinder single-acting two-stroke oil engine, developing about 10,000 b.h.p. Speed, 18 knots, fully loaded. Launch, July 8.

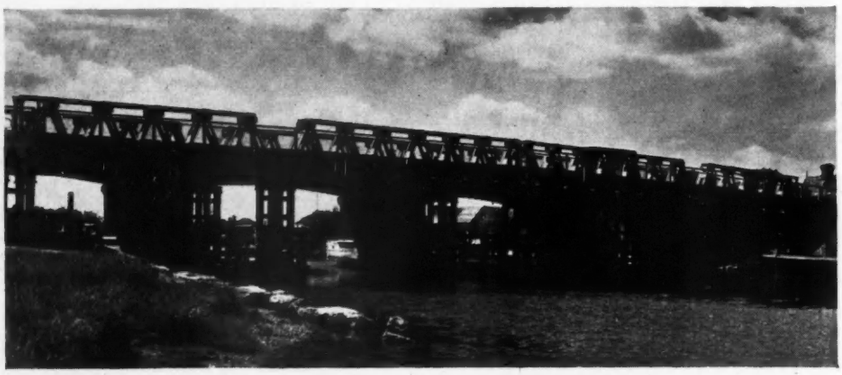
M.S. "POLLUX."—Twin-screw dredger built and engined by Chantiers et Ateliers Augustin Normand, Le Havre, France, for the French mercantile marine. Main dimensions: 151 ft. 11 in. by 27 ft. 11 in. by 7 ft. 6 in.; displacement, 424 tons. Two double-reduction geared gas turbines, together developing 1,800 h.p. Speed, 15 knots. Launch, July 16.

S.S. "BALLARAT."—Single-screw cargo vessel, built and engined by Alexander Stephen and Sons, Ltd., Glasgow, for the Peninsular and Oriental Steam Navigation Co., London, E.C.3. Designed for the company's Australian wool trade. Main dimensions: 490 ft. between perpendiculars by 69 ft. by 43 ft. to shelter deck; deadweight capacity, 12,790 tons on a draught of 29 ft. 9 in.; gross tonnage, 9,300. Triple-expansion geared steam turbines developing 11,000 s.h.p. in service. Steam supplied by two Foster Wheeler boilers. Service speed, 18 knots. Trial trip, July 27.

H.M.S. "LANTON."—Twin-screw coastal mine-sweeper, built by Harland and Wolff, Ltd., Belfast, for the Admiralty, London, S.W.1. Main dimensions: 152 ft. by 28 ft. 9 in. by 14 ft. 9 in.; armament, three small guns. Diesel propelling machinery supplied by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire. Launch, July 30.

M.S. "VIKAREN."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by the Götaverken Shipyard, Gothenburg, for the Rederiaktiebolaget Transatlantic, Gothenburg, Sweden. Main dimensions: 426 ft. overall by 57 ft. 6 in. by 35 ft. to shelter deck; deadweight capacity, about 7,000 tons on a draught of 23 ft. Götaverken seven-cylinder single-acting two-stroke Diesel engine, developing 3,900 b.h.p. at 120 r.p.m. Loaded speed, 14½ knots. Launch, August 2.

S.S. "STANPOOL."—Single-screw cargo vessel, built by William Gray & Co., Ltd., West Hartlepool, for the Stanhope Steamship Co., Ltd. (Manager: J. A. Billmeir), London, E.C.3. Main dimensions: 420 ft. between perpendiculars by 57 ft. 3½ in. by 37 ft.; deadweight capacity, 10,060 tons on a draught of 27 ft.; gross tonnage, 7,351. Triple-expansion steam engine working in conjunction with a Bauer-Wach exhaust turbine, constructed by the shipbuilders' Central Marine Engine Works. Steam supplied by three oil-fired cylindrical boilers. Service speed, 12 knots. Trial trip, August 9.



Replacement bridge at Walton-on-Thames built for the Middlesex County Council. It has four spans (two of 50 ft., two of 65 ft.) with a 20 ft. roadway decked with reinforced concrete.

REPLACING UNDER-STRENGTH BRIDGES

MAINTAINING A STOCK

A road bridge collapsed at Ardrossan, Scotland, in April last year, and a trailer with an important machinery load fell through on to a railway line beneath. As was reported in our issue of January 8, of this year (page 40), it was a well-built bridge, sound in materials and structure up to the moment of collapse, but it had never been renewed, altered or strengthened in the main structure since it was built in 1878. It had carried, with ample safety, the traffic of 85 years ago, and had often been used for loads of up to 70 tons in the ensuing years of increasingly heavy traffic, but the load which broke through at mid-span was over 106 tons – inconceivable as a single traffic load when the cast-iron girders of the bridge were laid down.

This example, together with the recent disaster in New Zealand where sudden heavy flooding so weakened piers of the Tangiwai bridge that it collapsed under the weight of a Wellington-Auckland express, underline the attention which has been aroused in both countries to the whole matter of bridge capacities. They were isolated happenings and resulted from abnormal loads, but reports made by the Ministry of Transport here, and by the Ministry of Works in New Zealand, indicate, at the very least, the possibility of a progressively higher incidence of danger to life and property, disruption of communications and delay and loss in commerce and industry.

The problem is world-wide, but in Britain alone there are 7,000 bridges which are under-strength, 1,500 of which are on main trunk routes. A New Zealand survey in 1947 showed that 300 bridges needed urgent replacement out of a total of 700 scheduled for renewal at an early date. By 1952, less than a third of the New Zealand programme had been completed and, although better progress has since been made, the position must still be critical, since a high proportion of the " weak " bridges were built of timber between 30 and 60 years ago, for a limited life and for horse-drawn loads. In Britain, most of the " weak " bridges were built over 50 years ago when loads were much lighter, but difficulties also arise where headroom is too low, or where narrow roadways cause traffic bottlenecks on important routes.

The re-building programmes which are now vitally necessary will take many years to complete and the financial problem will be a serious one. Evenly distributed progress cannot be expected; re-routing can only reduce the risk of damage to some extent, and municipalities or councils will have to expect sudden calls for urgent work where traffic loads approach or have reached the maximum. There is always a danger, moreover, that materials may not be to hand when most urgently needed and, for this reason, and in order to spread the cost, stockpiling of bridge materials may be advisable, using such equipment as the Callender-Hamilton standard bridge, made by British Insulated Callender's Construction Company, Limited, 30 Leicester-square, W.C.2.

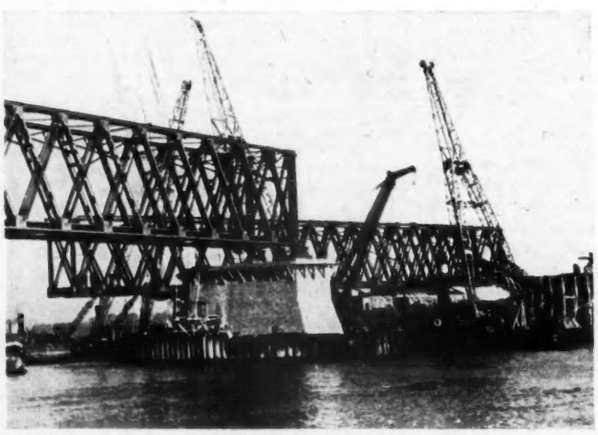
The components of these bridges, made of galvanised steel, do not suffer in storage through corrosion, are available for immediate building and are easily handled as well as readily transported. The possibilities in this direction have been illustrated recently by the replacement bridge built for the Middlesex County Council at Walton-on-Thames, by Dorman, Long and Company, Limited, Middlesbrough, and shown in the top picture.

The Callender-Hamilton material from which this bridge is constructed was bought for stock by the Middlesex County Council for emergency use in case of damage during the war. It was delivered 12 years ago and lay in its original storage site at Mogden Purification Works until it was withdrawn for this particular use. Storage was in the open, without cover, and much of the material, particularly the angles, were closely nested, yet in spite of the exposure to all weathers and the very corrosive atmosphere of the sewage works, the galvanising of each part is reported to have remained in excellent condition.

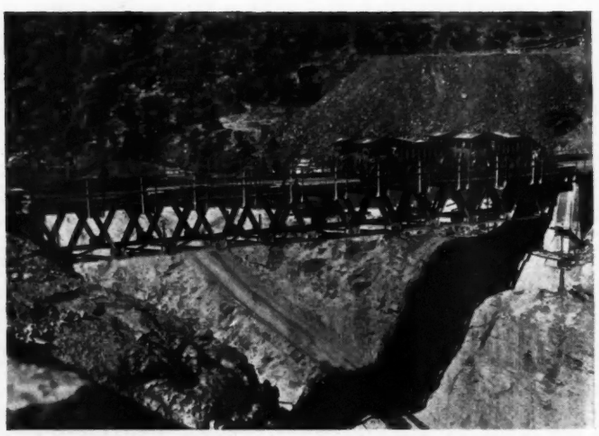
The old bridge at Walton-on-Thames was a typical example of the unsafe structure covered by the Ministry report. It was built in 1878, of wrought-iron lattice construction on 14-in. deep girders with a timber deck using piers which were already old at that time. In 1900, it was strengthened with additional girders, and in 1912 the decking was replaced with steel troughing filled with concrete, with a footpath on one side only. In summer, pedestrians crowded across the bridge and combined with the heavy traffic of the A244 road to create highly congested conditions.

No actual fault developed in the structure, but it was decided that modern loads were far too heavy for safety and the new bridge has been designed to carry full 15-unit Ministry of Transport loading. The roadway will be used only by vehicles. Pedestrians will cross on a cantilevered footbridge which has been added outside the main structure, and on the old bridge which will be closed to vehicular traffic.

The new bridge is of double-truss construction in four spans (two of 50 ft. and two of 65 ft.), with a 20-ft. roadway decked with reinforced concrete. Support is on 32-ft. long piles sunk into clay which was found at 30 ft. under a deep



Hoisting into position one of the two 240-ft. spans for a railway bridge in Holland.



A 120-ft. span double-carriageway bridge for the Roxburgh hydro-electric project, New Zealand.

gravel bed. All trusses were constructed on the bank and swung into position by a floating crane, construction, placing and filling-in being easily handled by a team of four or five.

Other bridge replacement operations which have been carried out on main roads in Britain during or after the war using Callender-Hamilton equipment have numbered 15, of which about half have been designed for normal M.O.T. loading and the remainder (on trunk routes) for super-heavy loading. This makes no mention of the many Callender-Hamilton bridges shipped to the Continent for use in the rehabilitation of the war-devastated road systems of Northern France and Holland, or of the large tonnage sent orerseas for opening up under-developed territories. An example of a bridge being erected for the Netherlands State Railways is illustrated opposite; similar orders have recently been placed by the Norwegian State Railways who have ordered three bridges of 190-ft. span. Also opposite, is illustrated a small 120-ft. span double-carriageway bridge for the Roxburgh hydro-electric scheme, New Zealand.

HELICAL CARBIDE-TIPPED CUTTERS

HIGHER SPEEDS AND IMPROVED SURFACE FINISH

The demand for improved surface finishes and faster cutting speeds which continually faces the production engineer has resulted in the development of helical milling tools with tungsten-carbide cutting edges. These tips give the tool a greatly increased working life, and make it suitable for machining high-tensile steels. Tips of this nature have been used for some time on straight-bladed cutters but, due to the fact that this type of cutter has most of its blade in contact with the work as the cut is taken, there is greater tendency to create chatter and produce premature crumpling of the chip, thereby causing a poor surface finish.

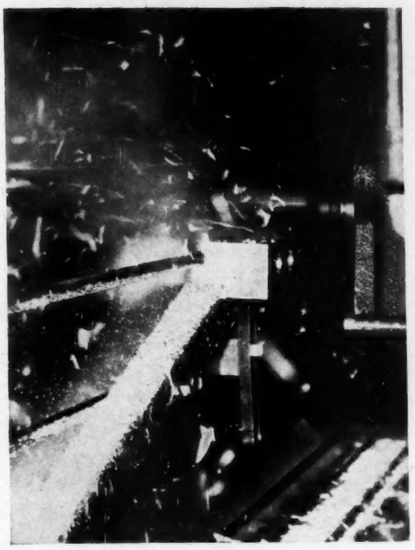
The Boeing Aircraft Corporation, who introduced the tipped helical-cutter in the U.S.A., have obtained finishes of 20 micro-inches on toughened metals. Short Brothers and Harland, Limited, Queensland Island, Belfast, N. Ireland, after a period of development work, have now also adopted slotting cutters of this type. Their first experimental cutter, which has a diameter of 4⅛ in., and cutting width of 7 in. with a helix angle of 20 deg., is shown on the left of the illustration below.

The development of the cutter was carried out in conjunction with the Production Tool Alloy Company, Limited, Sharpenhoe, Beds., who were concerned with the problem of moulding and brazing the carbide tips to the tool body. Consideration was first given to using a bit 7 in. in length, but it was decided that a number of small lengths averaging 2 in. would be more economical and would simplify the task of brazing. The tips nearest the shank were made of different lengths so that all the joints would be covered by the preceding blade, and the joints between each piece were relieved to form chip breakers.

The following procedure was adopted when brazing the tips to the cutter body. The body was pre-heated to about 250 deg. C., and the first tip, which was also pre-heated, was laid on to the seating at the arbor end of the cutter. The tip was then brazed in position using a blow-torch and fluxed at approximately 600 deg. C. The next tip went into the adjacent flute and so on working down the body leaving a 0·02-in. to 0·03-in. gap between the ends of the tips. After two-thirds of body had been tipped in this manner, it was allowed to drop in temperature to 150 deg. C. and the remaining tips brazed on. This was done to reduce the stress built up by irregular contraction rates of the parent body, as the coefficient of expansion of carbide is approximately half that of steel. For this reason also, a 0·3-in. gap between each blade was filled with solder to act as a buffer. On completing the brazing of the tips, the body was completely immersed in Kieselguhr oil and allowed to cool.

Because of the increased loads that this cutter was required to withstand, it was necessary that it should be as rigid as possible and be held firmly in the spindle. Failure to consider this point could have resulted in the fracture of the tips or an unsatisfactory surface finish. The cutter was machined from a forging using a No. 50 British Standard shank, and the flanged shoulder separating the arbor from the working end was drilled with four holes through which bolts were screwed into the nose of the spindle.

To facilitate grinding the tips, a trigger slot, which can be seen behind the tip and running parallel to it in the lower illustration, is cut when machining the tip pockets of the cutter body. It is ⅛ in. behind the face of the tip pockets and was cut by the same tool as was used for cutting the pockets without changing the diameter setting.



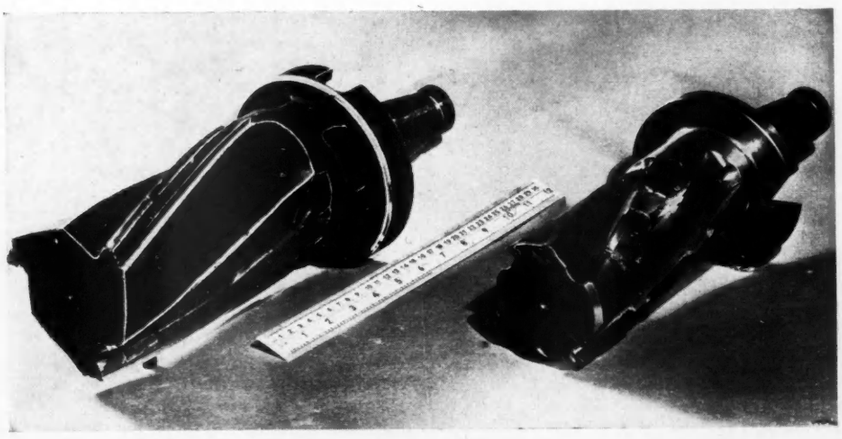
The helical tipped cutter in the illustration is machining a light alloy at 3,500 r.p.m. with a 48 in. per min. feed.

When face grinding, an arm attached to the machine engages with the trigger slot and twists the cutter by running along the slot as each pass is made. The face is usually ground with a diamond cup wheel and the best results have been obtained with wheels of small diameter. Tests have shown that this slot in no way interferes with the chip stream and, provided it is situated as far away as possible from the tip pocket, no weakening of the blade area is incurred.

On the three-bladed cutter, a further aid to grinding was introduced by drilling holes of ¼ in. diameter in the face behind the cutting edge. Steel pins faced at one end with tungsten carbide were made to fit the holes and held by grub screws, so that they protruded radially from the body. After grinding the cutter periphery, the diameter could be checked by measuring from the face of the tips to the outer nose of the plug.

Cutters of this type have been used with a Wickman spar milling machine for cutting light-alloy components having a 5-in. wide face, at 1,200 r.p.m. and feeds ranging from 36 in. to 88 in. per minute. The depth of cut taken varied from ⅛ in. to $\frac{1}{16}$ in., and the surface finish obtained was said to be superior to that obtained with a straight-bladed tipped cutter. When profiling an aircraft centre section on a Cincinnati 36-in. Hydrotel machine, a helical-tipped cutter was operated at 4,300 surface ft. per min. and was limited to a feed of 16 in. per minute, due to the behaviour of the tracing attachment. Some idea of the cutting speeds possible may be judged from the illustration above.

Among the other helical cutters that have been tested with tips are the four-bladed cutter, also shown on the left, and various sizes of cutters from ⅝ in. to 1½ in. in diameter and having a parallel shank for collet holding. With these smaller cutters, a fractured tip can be replaced in 20 minutes. Some interesting results have been obtained by using a ⅞-in. diameter three-bladed 20-deg. left-handed cutter of zero radial rake against steel which had been heat-treated to 156,000 lb. per sq. in. tensile and had to be profiled after being hard-chromed. Previously, one high-speed end mill had been used per part. By using a carbide cutter, at 850 r.p.m., 20 components were machined with only one regrind.



Three-bladed and four-bladed tungsten-carbide tipped helical-cutters. The cutting edge is 7 in. long and is built up from lengths of moulded carbide tips averaging 2 in.

Labour Notes

EMPLOYMENT RECORD MAINTAINED

During June, the number of persons in civil employment was increased by a further 36,000, most of whom were women. This brought the total number of people engaged in industry, commerce and services of all kinds to 22,466,000 and constituted a peace-time record. Of this total, 14,954,000 were men and boys, and 7,512,000 women and girls.

There was a seasonal increase of 19,000, mainly at hotels and in the catering trade, in the number of persons employed in professional, financial and miscellaneous services. In the manufacturing industries as a whole, there were 10,000 more persons at work. This was the result of an increase of 11,000 in the food, drink and tobacco industries, and a rise of 5,000 in the engineering group of industries, partially offset by a decrease of 6,000 in the clothing industry.

Statistics issued by the Ministry of Labour and National Service show that the number of persons registered as unemployed decreased by 19,400 between June 14 and July 12. The total of 220,100 at July 12 was the lowest since September, 1951, and it included 11,300 persons who were only temporarily disengaged.

Unemployment at July 12 was only 1·0 per cent. of the estimated total number of employees, compared with 1·1 per cent. at June 14 and 1·3 per cent. in mid-July last year.

FUTURE OF RENFREW AIRPORT

Various conflicting reports have been in circulation lately concerning the future of the British European Airways Corporation's engineering-maintenance base at Renfrew Airport. During the course of the past nine months, detailed consultations have been in progress between the trade unions concerned and the management of the Corporation regarding the future of the base.

In a statement issued by the B.E.A. earlier this month, it is pointed out that the discussions have arisen owing to the coming withdrawal of all Viking aircraft from the Corporation's service in October, and the increasing concentration in the use of the new pressurised Viscount and Elizabethan aircraft, in consequence. These latter aircraft, it is declared, must be based on London Airport, which is the centre of the organisation's operations.

In addition, the Corporation's fleet of Pionair DC-3 aircraft, now based on Renfrew Airport, will be gradually reduced during the course of the next few years, as the new aircraft are brought into service.

Having taken these circumstances into consideration, the board of B.E.A. have come to the definite conclusion that substantial financial economies would result from the transfer of the remaining work on Pionair aircraft from Renfrew to London Airport and the removal of a proportion of such of their skilled engineering staffs in Scotland as would be able and willing to come to London. Operatives so transferring would be assured of steady employment.

TRADE-UNION ATTITUDE

The basis of these economies, the statement continues, has been disputed by the trade unions and an offer by the Corporation to submit the figures to an independent assessor has been declined as unacceptable. The unions appear to have taken the view that " as the matter has now become more or less a political issue it is up to the Minister of Transport and Civil Aviation to make a personal decision."

The Corporation naturally regrets the upheaval which would result from the transfer of its Renfrew staffs, but the coming withdrawal from service of the Viking aircraft means that the base at Renfrew will inevitably decline in usefulness and, even were the move to be further delayed at the taxpayer's expense, its eventual closure could be no more than postponed.

Work on Pionair aircraft, like that on the Vikings, must end as new types of machines come into service. To divide the maintenance of the Viscount and Elizabethan aircraft between London Airport and Renfrew, the Corporation maintains, would entail heavy additional costs. The Corporation is certain that, on commercial and economic grounds, the transfer should take place.

The board of the B.E.A. are of the opinion that an investigation by a public court of inquiry, as has been suggested by some of their employees at Renfrew, would be " quite inappropriate " to the situation. Nevertheless, in view of the broader issues involved, such as the requirements of light industry in Scotland, the Corporation has sought the views of the Minister on whether these wider national issues should prevail over what would be, otherwise, a normal commercial decision.

At the same time, in order to ensure that its commercial view is demonstrable, the Corporation has decided to submit the figures on which it bases its conclusions to the scrutiny of an independent assessor.

RAILWAY WAGE STRUCTURE DEADLOCK

Unfortunately, the progress which attended discussions on a new wage structure for the railway services a short time ago has not been maintained. Early this month, a state of deadlock was reached, largely owing to offers of increased rates by the British Transport Commission falling short of the demands put forward by the three principal railway unions.

A further meeting between the parties took place on August 13, without, however, any definite progress being made. A brief joint statement issued subsequently merely announced that agreement could not be reached and that the trade-union representatives had declared their intention of reporting back to their respective executive committees. No arrangements had been made for any further joint meeting.

Mr. J. G. Baty, general secretary of the Associated Society of Locomotive Engineers and Firemen, said afterwards that the margin between his union's proposals and the offer of the B.T.C. was so wide that the union had had to reject the offer completely. The executives of that union, the National Union of Railwaymen, and the Transport Salaried Staffs' Association are due to meet shortly.

ENGINEERING WAGES

As had been expected, wage rates in the engineering and cognate industries were discussed at some length at the annual conference of the Confederation of Shipbuilding and Engineering Unions at Brighton last week.

In his opening address to the conference, Mr. H. G. Brotherton, the President of the Confederation, emphasised the view that higher wages should follow higher production, whatever the level of the cost of living might be. The relation of wages to living costs was indeed an urgent and significant factor in wage movements, but it should not be, he urged, the only criterion.

If it were, working people would be in a condition of stalemate, working to live and living to work, with no social or cultural development to look forward to in the future. Improvements in technique and developments in manufacturing methods would merely add to the profits of the employers.

The exports of engineering firms were improving and it was clear that the employers could afford to grant improvements in the conditions of their workpeople. The only question to be considered was when, and in what form, a new wage claim should be presented.

The apparently high average earnings in the industry included payments for overtime and special efforts by persons engaged on piecework, and disguised the fact that many operatives received little more than minimum rates.

NEW WAGE STRUCTURE DEMANDED

A number of motions, dealing with various aspects of the wage question, had been submitted to the conference, and, on the second day, after an intensive struggle behind the scenes, a composite resolution, calculated to satisfy all the parties concerned, was submitted by the standing orders committee.

The resolution instructed the Confederation's executive council to commence negotiations immediately for a new wage structure in the engineering industry, including the amendment of existing wage scales in such a way as to provide all employees with substantial increases. Claims were also to be presented, according to the resolution, for shipyard employees and all other persons for whom the Confederation negotiated.

The adoption of this motion was moved on the following day by the Amalgamated Engineering Union, and it was eventually carried unanimously. Among the speakers in the debate were representatives of the boilermakers', electricians', general workers', vehicle builders', and foundry workers' unions. In general, there appeared a hope that the existing differentials between the wages of skilled and unskilled employees might be widened and, possibly, that additional classes of semi-skilled workers might be established.

Several delegates expressed their concern at the " protracted " nature of previous wage negotiations and feared that a similar fate might befall the new claim. They suggested that, in such circumstances, interim increases must be demanded, especially in the case of the lowest-paid employees.

A resolution was moved by the Transport and General Workers' Union urging that the Confederation should make prompt use of machinery already available, to avoid delays. This was regarded, apparently, as an effort to tie the leaders and met with much opposition. It was disposed of by proceeding to the " next business."

PROPOSED NATIONALISATION OF THE ENGINEERING INDUSTRY

On the second day of the conference, there was a debate on nationalisation, based on the Confederation's proposals, as outlined in its *Plan for Engineering*. This scheme lays down suggestions for nationalising outright some sections of the engineering industry and for establishing public control over others.

It was this plan that Mr. Arthur Deakin, the general secretary of the Transport and General Workers' Union, forthrightly condemned as a " mumbo-jumbo of meaningless words and phrases " at last year's conference of the Labour Party. Subsequently, discussions on the plan, between the Confederation and the Trades Union Congress, were suspended.

After a somewhat stormy debate, during which the views of Mr. Deakin and his union were ably defended by a delegate of the T.G.W.U., a motion re-affirming belief in public ownership and calling for a national campaign to secure its early implementation was adopted by a majority.